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PROCEEDINGS OF THE WORLD SYMPOSIUM ON WARM-WATER POND FISH CULTURE

ACTES DU SYMPOSIUM MONDIAL SUR LA PISCICULTURE EN ÉTANG À TEMPÉRATURE ÉLEVÉE

ACTAS DEL SIMPOSIO MUNDIAL SOBRE PISCICULTURA EN ESTANQUES DE AGUA TEMPLADA

Rome, 18-25 May 1966
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PROCEEDINGS OF THE FAO WORLD SYMPOSIUM ON WARM-WATER POND FISH CULTURE

ACTES DU SYMPOSIUM MONDIAL ORGANISE PAR LA FAO SUR LA PISCICULTURE EN ETANG A TEMPERATURE ELEVEE

ACTAS DEL SIMPOSIO MUNDIAL DE LA FAO SOBRE PISCICULTURA EN ESTANQUES DE AGUA TEMPLADA

Rome, Italy, 18-25 May 1966
Rome, Italie, 18-25 mai 1966
Roma, Italia, 18 a 25 de mayo 1966

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VOLUME II - REGIONAL AND COUNTRY REPORTS

VOLUME II - RAPPORTS REGIONAUX ET NATIONAUX

VOLUMEN II - INFORMES REGIONALES Y NATIONALES

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ORGANISATION DES NATIONS UNIES POUR L'ALIMENTATION ET L'AGRICULTURE
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Rome, May 1967 Rome, mai 1967 Roma, mayo 1967

PREPARATION OF THIS VOLUME

This is the second volume of the Proceedings of the FAO World Symposium on Warm-water Pond Fish Culture and contains the regional and country reports contributed. Those experience papers which are essentially country reports are also included in this volume.

The first volume (see inside back cover) contained the report of the Symposium and the subsequent volumes will contain the review, experience and working papers.

The views expressed in the contributions are those of the authors and not necessarily of the Food and Agriculture Organization of the United Nations.

Dr. (Mrs.) Rosemary McConnell and Dr. Homer Swingle assisted in the editing of some of the contributions.

PREPARATION DE CE VOLUME

Ce volume est le second des compte-rendus du Symposium mondial de la FAO sur la pisciculture en étang à température élevée. Il contient les rapports régionaux et nationaux qui ont été présentés. Les compte-rendus d'expérience qui sont principalement des rapports nationaux sont également inclus dans ce volume.

Le premier volume (voir l'intérieur de la couverture) contenait le rapport du Symposium et les autres volumes renfermeront les revues, les documents sur l'expérience acquise et les documents de travail.

Les opinions exprimées dans les documents sont celles des auteurs et pas nécessairement celles de l'Organisation des Nations Unies pour l'Alimentation et l'Agriculture.

Madame Rosemary McConnell (Dr.) et Dr. Homer Swingle ont aidé à préparer plusieurs documents pour la publication.

PREPARACION DE ESTE VOLUMEN

Este es el segundo volumen del Simposio Mundial de la FAO sobre Piscicultura en Estanques de Agua Templada y contiene los informes regionales y nationales que fueron presentados a la Reunión. Las monografías sobre experiencias que son principalmente informes nationales, también están incluidos en este volumen.

El primer volumen (véase el dorso de la cubierta) contiene el Informe sobre el Simposio y los volumenes posteriores abarcarán los documentos de información, experiencias y trabajos.

Los puntos de vista expresados en los documentos presentados son las de los autores de los mismos y no reflejan necesariamente los de la Organización de las Naciones Unidas para la Agricultura y la Alimentación.

Los Drs. (Sra.) Rosemary McConnell y Homer Swingle prestaron su colaboración para la redacción de algunos de los documentos.

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A REVIEW OF CULTURE FISHERIES ACTIVITIES IN INDIA

by

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I/RR-1

A REVIEW OF CULTURE FISHERIES ACTIVITIES IN INDIA

Abstract

Pisciculture, though an age-old industry in India, was practised only in a few States in Eastern India and was based on the empirical knowledge of the farmers. With the establishment of Fisheries Departments in the states extensive surveys of the fishery resources were initiated, but much headway in piscicultural research was not made until after Independence.

With the attainment of Independence and an emphasis on greater food production, fish culture activities were expanded to cover almost the entire country and research organizations established to scientifically investigate fish culture problems. Considerable advancement has since been made in various fields. A large number of fish seed collection centres have been established and the technique of spawn collection improved; survival rate during rearing from spawn to fingerling stage appreciably increased; mortality during transport of fish seed greatly reduced; swamps and other derelict waters reclaimed by eradicating or controlling the aquatic weeds; bundh breeding techniques of Indian major carps improved and activities expanded; and, both the Indian major carps and the Chinese carps successfully bred by administration of fish pituitary extracts. A large number of fish breeding centres have been established.

LA PISCICULTURE EN INDE - ETUDE GENERALE

Résumé

La pisciculture, quoique étant en Inde une activité séculaire, n'était pratiquée que dans quelques Etats de l'Inde orientale et était fondée sur des connaissances empiriques. Avec la création dans divers Etats de départements des pêches, des enquêtes approfondies sur les ressources piscicoles ont été entreprises, mais la recherche dans ce domaine n'a fait de réels progrès qu'après l'indépendance.

L'accession à l'indépendance s'est accompagnée d'un souci grandissant d'accroître la production alimentaire, aussi les activités piscicoles se sont-elles étendues à la quasi-totalité du pays en même temps qu'étaient créées des organisations de recherche chargées d'étudier de manière scientifique les problèmes liés à la pisciculture. Des progrès remarquables ont été faits dans divers domaines: un grand nombre de centres de collecte d'oeufs de poisson ont été établis et la technique de ramassage du frai a été améliorée; le taux de survie des alevins en cours d'élevage s'est notablement élevé; la mortalité des oeufs de poisson en cours de transport a diminué considérablement; des marécages et autres plans d'eau délaissés ont été récupérés par l'élimination ou le contrôle des plantes aquatiques; les techniques d'élevage des principales carpes indiennes dans les bundh ont été améliorées et développées; enfin, on a réussi à faire reproduire les principales carpes indiennes et les carpes chinoises en leur injectant des extraits de glande pituitaire de poisson. Un grand nombre de centres d'alevinage ont été créés.

RESEÑA DE LAS ACTIVIDADES PISCICULTURALES EN LA INDIA

Extracto

Aunque la piscicultura es una industria antigua en la India, sólo se practicaba en pocos Estados de la India oriental y estaba basada en el conocimiento empírico de los cultivadores. Con la creación de Departamentos de Pesca en los Estados se iniciaron amplios estudios de los recursos pesqueros si bien no se lograron grandes avances hasta después de la independencia.

Al alcanzar la independencia y concederse gran interés al incremento de la producción de alimentos, se ampliaron las actividades pisciculturales hasta abarcar casi la totalidad del país y se establecieron institutos de investigación para estudiar científicamente los problemas de la piscicultura. Desde entonces se ha hecho un gran progreso en distintos sectores. Se ha incrementado un gran número de centros de recogida de material ícticо de repoblación y se han mejorado las técnicas de recogida de la freza; se ha incrementado la tasa de supervivencia durante la cría desde la eclosión hasta la fase de jaramugo; se ha reducido grandemente la mortalidad durante el transporte del material para repoblación; se han rehabilitado zonas pantanosas y otras aguas abandonadas mediante la eliminación o el control de las plantas acuáticas; se han mejorado y desarrollado las técnicas de cría bundh de las principales carpas indias, y se ha obtenido la reproducción de las carpas principales indias y de las carpas chinas mediante la administración de extractos pituitarios de pescado. Se ha establecido un gran número de centros de cría de peces.

I/RR-1

1 INTRODUCTION

India has vast culture fishery resources. There are innumerable small and large ponds and tanks, jheels and bheels, swamps, and brackish-water lagoons and bheris. According to an estimate, 18,269,104 acres (7,307,642 ha) of cultivable waters exist in India (Anon., 1962b). Large areas of these potentially rich cultivable waters are at present lying fallow and could be made to produce considerable quantities of fish if developed on sound scientific lines. The production from existing cultivable waters could also be further enhanced by adopting improved techniques of fish culture.

2 PISCICULTURE BEFORE INDEPENDENCE

Though an age-old industry, mentioned as early as 1127 A.D., fish culture has been mainly confined to the eastern states of Bengal, Bihar and Orissa. Here great potentialities for a fish trade have always existed, fish being the main diet of the rice-eating population of this region (Day, 1873; De, 1910). In the plains and deltaic regions of these states a large number of ponds have been dug within the past two centuries for construction work on railways and buildings, creating new waters. A large number of bheels and lakes, cut-off portions of river courses, also exist which have come into being due to natural causes. A net-work of major rivers providing the young of quick-growing carps, and the richness of the pond soil, helped the development of the industry. As the culturable carps (mainly catla, Catla catla, rohu, Labeo rohita, mrigal, Cirrhina mrigala and calbasu, Labeo calbasu) commonly called the major carps, did not breed in confined waters, the fishermen devised effective methods of collecting their spawn from the flooded rivers, the Ganga, the Mahanadi, and their tributaries during the monsoon months. Others explored ways of breeding them in confined areas by creating the flood conditions artificially and were successful in their attempts. Such ponds, where carps were made to breed, were designated bundhs. The eggs, collected from these bundhs, were and are still hatched in earthen pits in the vicinity of the bundhs where large-scale mortality is a common feature. The methods of transportation of spawn from the collection or production centres to the nearby ponds, or to markets also entailed heavy mortality.

No attention was ever paid to growing the spawn in nurseries before stocking them in the larger water bodies, which resulted in poor yield. To many, fish culture consisted of purchasing some spawn from the market, putting them in the pond and finally reaping a harvest at the end of the year. In brief, though an ancient industry, fish cultural practices in India lacked a scientific background. The empirical methods, as developed by the local fishermen, were often wasteful and faulty, thus seriously limiting production and returns.

In the later half of the nineteenth century and early in the present century attempts were, however, made to culture exotic food fishes to develop the supply of fish in regions which did not have a rich indigenous fish fauna. Though gourami (Osphronemus goramy) was introduced first in 1841 in Calcutta, it did not survive and was reintroduced in 1865 in Madras (Raj, 1916).

Early in the present century, with the organization of Fisheries Departments in certain states, attempts were made to extend fish culture practices to other parts of India and to develop these on scientific lines. Notable amongst these are the efforts of the Madras Fisheries Department. On the recommendation of Nicholson (1915) a large fish farm was established in the State at Sunkesula (Krishna District) (now in Andhra Pradesh) in 1911 with the object of (i) stocking barren waters, (ii) supplying of live fish direct to the markets, and (iii) distributing larvicides. In subsequent years a large number of ponds, tanks, moats and irrigation reservoirs were stocked with major carp fry and fingerlings, mostly collected from the river Godavari and inundated paddy fields in the deltaic region of the river.

Further attempts at introducing exotic fishes, O. gorami from Java and Mauritius in 1916 (Nicholson, 1918; Hornell, 1920) at Sunkesula and Cyprinus carpio from Ceylon to Ootacamund in 1939, met with some success. The nesting and breeding habits of gourami, Mystus aor and M. seenghala were studied (Hornell, 1922). Experiments were started as far back as 1918-19 to determine the relative values of different kinds of artificial food, such as ground-nut and gingelly oil-cake (Hornell, 1920) and a district by district survey of irrigation tanks and other inland waters was made.

Though traditional practices of culturing fish and prawns in embanked brackish waters exist in West Bengal and in the low-lying paddy fields of Kerala where mullets (Mugil spp.), prawns (Penaeus spp. and Metapenaeus spp.), bhetki (Lates calcarifer), pearlspot (Etroplus suratensis), etc., constitute a catch, systematic attempts to culture brackish-water fishes in fresh and brackish waters, to utilize the coastal saline swamps and low-lying areas in the deltaic regions, were first made by Madras Fisheries Department. Etroplus suratensis was introduced in the fresh-water tanks of Salem district and the gun powder factory ponds of Madras in 1915, and later bred at Sunkesula (Hornell, 1922). Experiments to determine the best species of mullets for stocking the fresh-water tanks, and the methods to be employed in conditioning and transporting them, were undertaken. From 1931 onwards, the Department made initial attempts to acclimatize and grow the white mullet or milkfish, Chanos chanos, in various departmental ponds, the fry being plentiful on both the east and west coasts during May-June and to a limited extent in November (Ranganathan, 1961). Unfortunately, proper management techniques with regard to the culture of mullets and chanos have not so far been developed.

Other states followed Madras in matters of fishery research as Fisheries Departments were established, but little headway in piscicultural research was made. However, fairly exhaustive surveys for the development of fisheries were conducted in Bengal (Gupta, 1908; Naidu, 1939), Punjab (Dunsford, 1911), Uttar Pradesh (Eyde, 1923), Baroda (Moses, 1947), Mysore (Bhimachar, 1942) and Hyderabad (Rahimullah, 1944). Several pamphlets and bulletins were published by these departments to popularize fish culture. In Bengal, improvements in carp cultural methods were suggested by Sen (1941) and Hora (1943a-f, j and i; 1945d) in a series of articles to popularize and bring pond culture on scientific lines. Hora (op.cit.) suggested the extension of these practices to various parts of the country, and advocated the manuring of ponds and the removal of predators to increase production from culture ponds. The chief requirements of fish farms were formulated (Hora, 1945b) and suggestions were made to develop the salt water bheris of Bengal for fish culture (Hora and Nair, 1944). Studies on the diseases and mortality of fish in tanks and ponds, and transport of fish fry, engaged the attention of Khan (1939a and b, 1941, 1943b, 1944). The nesting and breeding habits of Osphronemus goramy were studied by Jones (1939), Kulkarni (1943) and Bhimachar et al., (1944), and its cultural possibilities by Spurgeon (1945) and Kulkarni (1946). However, the slow growth of the fish was perhaps the main reason for its not supporting a commercial fishery. Possibilities of murrel (Ophiocephalus spp.) and pearlspot culture were discussed by Hora (1945c), Bhaskaran (1946), Rahimullah (1946), and Chacko and Kuriyan (1947a and b). The Advisory Board of the Indian Council of Agricultural Research in its memorandum of 1944 directed the development of pond culture and also sponsored fisheries research by financing ad hoc schemes by state governments and universities which helped the study of the hydrobiology of certain inland waters and of the bionomics of the major food fishes of Madras and Bengal.

Utilization of sewage for fish culture attracted the attention of others (Moses, 1941), and a Symposium organized by the National Institute of Sciences of India in 1944 threw more light on the possibilities of utilizing the Calcutta sewage for piscicultural purposes. Effects of Calcutta sewage on fish (Nair, 1944a) and possibilities of developing sewage-irrigated fisheries in salt lakes (Bose, 1944) were discussed. Fowler (1944) drew attention to the biochemical aspects of sewage irrigation while Nair (1944b) suggested the raising of alternate crops of paddy and fish in the same field. However, it was felt that more work was necessary before recommending large-scale use of sewage for fish culture.

Studies on the bionomics and spawning of carps were made in the Punjab (Khan, 1938b, 1942, 1943a and 1945; Husain, 1945) and Bengal Fisheries Department (Das, 1917; Muzumdar, 1939; Ahmad, 1944, 1946; Hora, 1945a; Das and Das Gupta, 1945) and in the University of Calcutta (Mookerjee et al., 1944a and b; Mookerjee, 1945). The National Institute of Sciences of India organized a symposium in 1945 on the factors influencing the spawning of carps which brought to light various view points. The most important of them, which was to revolutionize carp culture in the years to come, was the suggestion made by Khan (1945 op. cit.) emphasizing the role of internal secretions in precipitating spawning which may be brought about by changes in the meteorological and chemical conditions. These factors were further studied in the Punjab and Bengal and also in Madras.

Biological control of mosquitoes which act as vectors in the spread of various diseases viz., malaria, filaria, dengue, etc., also received the attention of various workers (Wilson, 1917; Hora, 1927, 1937; Sen, 1937; Roy, 1938). Hora and Mukherji (1938) drew up a table for the identification of Indian fresh-water fishes and made certain observations on the relative utility of the probable larvivorous fishes of India. Although two exotic larvivorous fishes, Lebistes reticulatus and Gambusia affinis, were introduced into India in 1909 (Prashad and Hora, 1936) and 1928 (Gopinath, 1943) respectively, little work either on the indigenous or exotic species was done until the late thirties. Khan (1938a, 1943c) in the Punjab, Fraser (1938) in Poona, Hora and Nair (1938) and Job (1941a, 1943 and 1944) in Bengal and John (1940) in Travancore-Cochin worked on larvicidal fishes and advocated their culture. Etroplus suratensis and E. maculatus (Sebastian, 1942) and Horaichthys setnai (Job, 1940) were further added to the list of larvicides. Interest in the control of guinea-worm disease was evinced since Megalops cyprinoides (Setna and Kulkarni, 1940) and Ambassis spp. (Job, 1941b) were found to feed principally on Cyclops, which act as vectors in the spread of the disease. The Government Fish Farm at Chetput, Madras, was established specificially for the culture and distribution of larvicidal and cylopscidal fishes.

3 PISCICULTURE AFTER INDEPENDENCE

Soon after Independence, emphasis was laid on greater food production; fish culture activities were expanded to cover almost the entire country, and the industry developed at the hands of both the Governmental agencies and private pisciculturists. Any large-scale program for the development of fisheries has necessarily to be based on the solid foundation of scientific research. The Government of India established the Central Inland Fisheries Research Station (now Institute) at Calcutta in 1947 to conduct scientific investigations for a proper appraisal of the inland fisheries resources of the country, and to evolve suitable methods directed towards their proper conservation, management and development. As the Government of India assumed direct responsibility for fisheries research under the present constitution of India, this Institute became the main centre for inland fisheries research. Local problems are still being investigated by the State Fisheries Departments, and this Institute maintains a close liaison with these and with the Universities doing similar work. The Institute established its Pond Culture Division at Cuttack (Orissa), in view of the facilities afforded by the State Fisheries Department to work at a number of fish farms in and around Cuttack, to evolve suitable scientific methods in regard to management of culture fisheries.

The problems of culture fisheries being many and varied, it was not possible to study all aspects simultaneously; top priority was given to improving techniques of collecting and rearing major carp fry, investigating carp culture practices to achieve maximum survival rate from spawn to fingerling stage, reducing mortality during transport, eradication of aquatic weeds from fish ponds, and inducing spawning of carps by artificial flooding of ponds and by injection of pituitary gland extracts (Bhimachar, 1959). Experiments to determine the suitability or otherwise of certain exotic species for culture in different parts of India were also undertaken. The increased need for fish seed for cultural purposes made a heavy demand on the Calcutta spawn markets, hence the Institute, alive to the need for quality fish seed for this purpose, organized the Fish Seed Syndicate in 1950. The object was to procure quality fish seed from surplus areas to supply to deficit states; this gave great impetus to the pisciculture industry. The Syndicate has, since its establishment, done

excellent work and is today the biggest fish seed trade organization in the country. It has not only effected considerable improvement in the transport of fish seed by rail and air, but also carries out large-scale rearing of fry in well prepared nurseries. Other organizations, viz., the General Marketing Company, the Eastern Fisheries Corporation, and the West Bengal Government-sponsored Fishermen Cooperative Society (now defunct) also sprang up and started undertaking export of fish seed on smaller scales.

3.1 Improvements in techniques of spawn collection

Rahman (1946) suggested that collection of carp spawn should be considered a technical job and expert catchers be registered, to save the wastage due to new men taking to this business. In the empirical method of collection there were serious drawbacks causing heavy mortality of spawn, either during collection itself or in the nursery ponds (Alikunhi, Chaudhuri and Ramachandran, 1952). Hence certain improvements were suggested, such as the proper fixing of the net so as to offer the least resistance to fast-flowing waters, changing the form of the receptacle (gamchha), removal of spawn from the gamchha at regular intervals, and keeping the sieve submerged in water when sieving the collections. It was also recommended that overcrowding during temporary storage in pits, hapas or hundies and any sudden change of hydrological environment should be avoided.

The growing need for carp fry necessitated searching for natural breeding grounds and new spawn collection centres. Carp spawn is now collected from the rivers on a very large scale by Governmental agencies in Uttar Pradesh, Madhya Pradesh, Bihar, Gujarat, Maharashtra, Orissa, Andhra Pradesh and Madras States in order to stock the public waters and meet the demand for fry by private pisciculturists. However, the non-availability, or low percentage of major carp fry in the collections in many states necessitates its import from Calcutta markets. About 10,000 to 15,000 fishermen are engaged privately in collecting spawn in West Bengal, Bihar and Orissa.

Despite the intensive collection of carp fry in certain sections of some rivers, a regular survey of such resources has been made only in a few cases(David, 1959; Ibrahim, 1961). No data are available, in most cases, of the quantities collected from year to year. A concerted effort is now being made by the Central Inland Fisheries Research Institute to prospect areas of quality fish fry occurrence, and towards standardizing the collection equipment and procedure (Anon., 1965).

3.2 Preparation of nursery ponds

Hora (1943a, e, 1945d) invited attention to the adopting of scientific methods of fish culture similar to agricultural practices, involving the use of at least three different kinds of ponds, nursery (60 x 40 x 4 feet, 20 x 13 x 1.3 m),rearing (100 x 80 x 5 feet, 33.3 x 26.6 x 1.6 m) and stocking (over half an acre in area, 0.2 ha, and about 6 to 10 feet, 2 to 3.3 m deep). However, efficient operations are only possible when the ponds are specially constructed for fish culture. Some states in India are experiencing great difficulties in the construction and designing of fish farms. Information is now being gathered on different soil conditions, water retention, surface features, etc. As digging ponds on flat land costs more than putting cross dykes in an already existing water body, the latter possibilities are being explored. In Orissa and Tripura where a large number of swamps exist, the Fisheries Departments undertook experiments on the removal of silt and aquatic weeds and dividing a big water sheet into a number of small, long and manageable ponds by cross bundhs. These experiments have proved that this is a much more economical way to construct ponds (Mitra, 1956a, b, 1957).

Till recently, no regard was ever paid to the intensity of stocking spawn and the preparation of ponds; this usually resulted in a poor survival rate. Exceedingly high rates of mortality of fry in nursery ponds (90 to 98.7 percent) have been reported from Orissa State (Alikunhi, Chaudhuri and Ramachandran, 1955b). The causes of mortality in the nursery ponds have been listed by Alikunhi et al., (1952, 1955a and b). To obtain maximum survival of fry, spawn has to be reared in small nursery ponds to the stage when the major carp fry could be

segregated easily from undesirable species and stocked in larger ponds for further growth and fattening. As the fry are very delicate, easily susceptible to diseases and predation, and with specific feeding habits, the nurseries have to be specially prepared. In perennial nurseries, management practices to increase the survival of young carp fry include: (i) drying the pond bottom to expose the soil to the sun for proper mineralization, (ii) removal of excess organic debris to prevent production of toxic gases and spread of epidemic diseases, (iii) removal of aquatic weeds, which not only harbour predatory aquatic insects, but deprive the water of nutrients for the production of the zooplankton forming the food of the fry, and also upset the ecological balance by supersaturation of oxygen (Alikunhi et al., 1951) or production of toxic substances by mass decay, (iv) eradication of predatory and weed fishes, which either feed directly on carp fry or compete with them for planktonic food (Alikunhi and Jhingran, 1951; Alikunhi, 1956, 1957).

3.2.1 Control of aquatic weeds and water blooms

Although the cheapest way to remove aquatic weeds from nursery and rearing ponds is by manual labour, anhydrous ammonia at 15 ppm N can also be used for their control. This also kills the predatory and weed fishes and fertilizes the pond with a nitrogenous fertilizer (Ramachandran, 1960). The water blooms can be controlled by repeated application of raw cowdung (Alikunhi, 1956) or covering the water surface with Lemna (Alikunhi et al., 1952) as is commonly done in Bengal.

3.2.2 Eradication of predatory and weed fishes

The role of predatory and weed fishes in spawn collection nets has been discussed by Karamchandani (1957) and their subsequent transfer to nursery ponds along with carp spawn is bound to affect the survival rate. Derris root powder at 4.6 ppm and Endrine at 0.1 ppm have been used to kill predatory and weed fishes effectively (Alikunhi, 1957; Barrackpore, 1964). Recently, some local plant poisons, such as powdered seed kernel of Croton tiglium (3 ppm), powdered seeds and dried leaves of Mallitice piscida (2 ppm and 10 ppm respectively), custard-apple seeds (Anona squamosa) and Euphorbia thirucalli, have been found to be quite effective and useful. Laboratory and field trials conducted to find a suitable agent for detoxification of Endrine-treated waters have indicated that though lime, sodium hydroxide, potassium permanganate, sulphuric acid and cowdung could serve the purpose, ordinary charcoal at 50 ppm appeared to be more suitable, as well as economical. It has also been observed that the presence of rich organic matter in the soil, or a thick algal bloom in the water mass, accelerated the natural detoxification phenomena (Barrackpore, 1964, 1965).

3.2.3 Manuring of ponds

The main food of spawn and fry being zooplankton (Alikunhi, 1952, 1958; Mitra and Mohapatra, 1956), a sustained high level of zooplankton production is essential during the rearing period. Artificial fertilization is used to increase productivity by making more nutrients available to the lower levels of the food chain, especially bacteria and phytoplankton. Perennial nurseries generally tend to be slightly acid, and therefore require to be corrected by addition of lime. Even in seasonal nurseries, lime at 200 to 300 lb/acre (222 to 333 kg/ha) is usually spread over the dry pond-bed to ensure the fullest utilization of additional manure. The pond owners are usually advised to use the same fertilizer which they are using for their lands, but being soluble in water its nutrient contents are immediately available, unless the water contains suspended soil colloids or considerable soluble iron which ties up the phosphates. Hence smaller applications are necessary for ponds than for soils. Application of manure prepared by composting water hyacinth, banana petioles, arum stem, Hydrilla verticillata and Ceratophyllum has been advocated by Saha (1953). Green manuring, by growing Sesbania sp. on the pond beds and crushing it after ten to fifteen days, is practised in the farms of Orissa. Experiments at the Pond Culture Division of the Central Inland Fisheries Research Institute showed that heavy manuring with cowdung in experimental cement cisterns resulted in the production of a rich crop of zooplankton within about two weeks. The application of raw cowdung gave a better result because the nutrients present therein were more readily available than in cowdung manure or dry cowdung, (Alikunhi, 1957).

The high production, however, lasted for only a short while and it was found difficult to maintain it over a long period. A large-scale field experiment showed that spaced manuring with an initial dose of 1,000 lb/acre (1,111 kg/ha) of cowdung followed up ten days later by five more supplementary doses, each of 2,000 lb/acre (2,222 kg/ha), every third day maintained a fairly high level of plankton production. The same quantity of manure applied in a single dose did not maintain similar high production (Calcutta, 1957). While organic manures have been used for a considerable time, the use of inorganic fertilizers is still experimental. Application of 18-8-4 N-P-K at 500 kg/ha have given very good results both in the preparation of nursery ponds and also in short-term rearing experiments (Barrackpore, 1965).

In addition to major nutrients, small quantities of manganese, zinc, copper, boron, cobalt and molybdenum are also needed for growth. The soils in India show deficiencies of boron, manganese and zinc in a number of instances, and while the effect of such deficiences has been studied to some extent on crop plants, little is known about their effect on fish growth or fish food. Preliminary experiments conducted in the cement cisterns at Cuttack have indicated that addition of manganese lead to a definite increase in the quantity of plankton produced (Barrackpore, 1961).

3.2.4 Assessment of food

The fry feed selectively and their feeding capacity is quite considerable (Alikunhi, 1952). Therefore, stocking density should be based on the quantity of such food items available in the environment. The former belief that major carp fry feed exclusively on unicellular algae has been disproved, and it is now known that the density of zooplankton in a nursery pond should be the basis to determine the intensity of stocking. A qualitative and quantitative estimation of plankton content is, therefore, necessary. A simple method of quantitative sampling was developed during the course of these investigations. A small conical plankton net made out of standard No.21 bolting silk, or fine muslin, open at both ends was fixed on to a circular metal frame 9 to 12 in (22 to 30 cm) in diameter and with a short handle, and a glass tube 3 to 4 in (7 to 10 cm) long and 1 in (2.5 cm) in diameter was tied to the lower tapering end. Samples of water are collected by a person standing in knee-deep water near the edge of the pond and stretching out his arm towards the centre of the pond. The surface of the pond is first slightly disturbed to disperse or mix the algal scum, if any, and the mug for collecting the sample then held with its mouth downward to about 6 in (15 cm) below the surface of water and gradually tilted to collect the water. If the plankton sediment obtained after filtering about 12 gallons (55 litres) of water and addition of a few drops of strong formalin is light brown or pale yellow in colour, i.e., with zooplankton predominating, and about quarter of an inch (6.4 mm) or more in height, i.e., over 3.0 cc in volume, the pond may be considered to be sufficiently rich for a stock of about 500,000 fry per acre (200,000 per ha) (Alikunhi *et al.*, 1955a). Mitra and Mohapatra (1956) considered an initial availability of 0.1 to 0.3 cc of zooplankton per fry as essential, and further observed that occurrence of phytoplankton blooms produces detrimental results, especially when zooplankton is poor and blooms persist for long periods.

3.2.5 Control of predatory insects

Predatory aquatic insects multiply rapidly between poisoning and stocking and have been found to take a heavy toll of fry as soon as the latter are released in the pond (Khan and Husain, 1947; Ganguly and Mitra, 1961; Gorai and Ray Chaudhuri, 1962). *Anisops* spp. can kill half inch (12.7 mm) fry, while *Laccotrephes* spp. and *Ranatra* spp. can kill even larger fry. The olive beetle, *Cybister* spp., and its larvae are highly predatory, and able to destroy fingerlings up to 2 in (5 cm) in length (Alikunhi, 1957). Larger insects and larvae can be controlled by gently dragging a fine-meshed cloth-net and destroying those collected.

The Bengal farmers separate notonectids and carp fry by spraying mustard oil in the *hapas*. Various vegetable oils were therefore tried. Linseed and mustard oil were found to be the most effective, but the former was slightly toxic to the young fry as well as to zooplankton. Owing to their high viscosity, vegetable oils spread very slowly on the water surface. Emulsions were, therefore, prepared by addition of soap wastes or ordinary cheap

washing soap solution, which facilitated easy spreading of oil as a thin film over the water surface. A quantity of soap equal to about one-third the weight of oil was sufficient to make a satisfactory emulsion. Under field conditions, oil at 50 lb/acre (55 kg/ha) of water surface yielded satisfactory results. The notonectids are killed within half an hour, and Ranatra spp., are also affected (Pakarasi, 1953). Higher doses, however, kill water boatmen, Cybister spp., larvae of other beetles and bugs as well. The operation should be performed on a windless day to be effective. As many of the beetles and bugs can fly out of water and migrate from pond to pond repopulating the cleared ponds, the stocking operations should follow twelve hours after the spray operation.

Experiments with oil of Alexandrian laurel (Calophyllum inophyllum, a vegetable oil common in Malabar and Orissa, water dispersible gammexane (0.1 ppm) which kills notonectids and prawns, and pure gamma isomer of benzene hexachloride (0.1 ppm), etc., have all proved to be quite effective, cheap and useful, as they do not affect the fish fry and zooplankton adversely to any great extent. Recently, Srivastava and Konar (1965) have reported that 0.5 ppm of DDVP (0:0 Dimethyl - 2:2 - dichlorovinyl phosphate, manufactured and sold as 'Nuvan' by Ciba Ltd., Switzerland) in the emulsifiable form effectively kills Nepa, Sphaerodema, Ranatra, Dytiscus, Dytiscus larvae, Hydrophilus and dragonfly nymphs in the laboratory within 6 to 58 hours. Ponds otherwise quite suitable and with a fairly high density of zooplankton have given poor survival of carp fry when they were not cleared of predatory insects.

3.2.6 Supplementary feeding

In systematic fish culture it is usual to add supplementary food to obtain higher yields, as the water may support only a limited crop of zooplankton even after fertilization. Additional advantages that accrue from supplementary feeding are (i) a higher density of stocking for better use of available natural food, (ii) better growth on a mixed diet, and (iii) residual manurial value of the feed. Preliminary experiments have shown that carp fry grow decidedly better when equal quantities of zooplankton and artificial food, rather than an excess of artificial food alone, are given, and that they consume more of the zooplankton than of the artificial diet in a given time. For the first two days, however, the fry hardly make any use of the artificial food. Laboratory experiments have shown that they feed avidly on rice bran and ground-nut oil-cake, or a mixture of the two, as soon as they start feeding. It is, therefore, clear that for the successful rearing of fry, the nursery ponds should be rich in zooplankton at the time of stocking, and that from the second or third day after stocking, the natural food, i.e., zooplankton should be supplemented by artificial food such as rice bran and oil-seed cake. Under field conditions the fry have to be fed once or twice a day with rice bran and, or, oil cake. These are more easily assimilated by the delicate fry if they are in a finely powdered state, when they will also remain suspended in the water column for a much longer period (Alikunhi, 1957). The artificial feed to be given to carp fry in nurseries is a 50:50 mixture of rice bran and mustard-oil cake starting with thrice the weight of the fry at the time of stocking for the first five days, increasing to four and five times in subsequent five day periods (Barrackpore, 1961).

Recently, laboratory experiments have indicated that dried and powdered shrimps and notonectids, certain cereals and pulses and fat-free proteins, individually or in a suitable combination, were more nutritive than oil cakes and brans which have been so far used as artificial feeds in pond culture (Barrackpore, 1965). Further observations are, however, in progress.

Some laboratory experiments were carried out at the Indian Statistical Institute, Calcutta, to study the effects of antibiotics and vitamins on carp fry particularly with a view to enhancing their survival during the period of fast growth and heavy mortality. These experiments have shown (i) that both antibiotics and vitamin B complex, with vitamin B_{12}, significantly enhanced survival rate in comparison with untreated controls (Das and Krishnamurthy, 1961a), (ii) that vitamin B complex without B_{12} did not have a significant effect (Das and Krishnamurthy, 1961b) and (iii) that cobalt nitrate with goat's stomach extract (1 ppm cobalt nitrate and 5 cc extract), a cheaper source of vitamin B_{12} as the micro-organisms in a ruminants' paunch synthesize B_{12} in the presence of cobalt, significantly enhanced survival rate (Das, 1959).

Fry are reared in the nurseries for a period of about two weeks where they attain a size of about 25 to 30 mm and have to be removed to larger rearing ponds. Different species develop different feeding habits; the food requirements of the fry increase appreciably and they need greater space for movement for proper health and growth. At this size carp fry can be easily distinguished from predatory and weed fishes. The preparation of rearing ponds is no less essential though less elaborate.

The advanced fry are grown in the rearing ponds to 100 to 150 mm length and stocked at 20 to 30,000 per acre (8 to 12,000 per ha) without feeding and 50,000 to 60,000 per acre (20 to 24,000 per ha) with feeding.

Experiments on intensive production and various stocking rates and ratios are in progress. Experiments to enhance the production of fish by liming, manuring and artificial feeding were carried out by stocking 3,750 fingerlings/ha in one of two combinations viz., catla, rohu and mrigal or catla, rohu and common carp (Cyprinus carpio) in the ratio of 4:3:3. The trials showed the better growth of common carp, and that the total production in ponds with common carp combination was higher than with mrigal combination. Catla grew better in ponds treated with oil-cake as manure than in ponds where oil-cake was used as an artificial feed.

3.3 Transport of fish seed

Transport of spawn and fry in earthen pots (hundies) on slings from seed collection centres for stocking in cultivable waters has been in practice since very ancient times in India (Job, 1951). The transport of fish seed of all culturable species over long distances without mortality has always been a problem. Although there were various indigenous practices intended to prevent mortality, these were inadequate. It was, therefore, necessary to find more effective ways of transporting large quantities of fish seed for meeting the increasing demand in remote areas. While maintenance of dissolved oxygen balance in the medium for transportation of spawn and fry is very important, inimical gases like CO_2 and NH_3 resulting from metabolic products and decomposition of dead young are also important as they cause mortality. Increasing concentrations of ammonia affect the young so adversely that they are unable even to utilize the dissolved oxygen present. Khan (1941) studied the oxygen requirements of C. mrigala while Basu (1950; 1951b; 1952) studied the physiological requirements of the eggs, larvae and fry of Indian carps and Motwani and Bose (1957), the active respiratory rates of L. rohita. Viswanathan and Tampi (1952) determined the oxygen consumption of Chanos in relation to size, while Job (1957) worked out its routine active oxygen consumption. Basu (1952) showed that spawn and fry of catla, rohu and mrigal consume the maximum amount of oxygen between pH 6.0 and 7.9 at 36° to 37°C and that dissolved oxygen below 0.5 ppm is fatal to both spawn and fry, whereas they can live for 24 hours or more with 0.5 to 1 ppm of O_2. But even at this concentration 2.5 to 5 ppm of CO_2 is lethal to spawn and 10 to 15 ppm to fry (15 to 40 mm long); at 2 ppm of O_2 and above, the lethal limit of CO_2 is increased to 100 ppm for spawn and 225 to 250 ppm for 15 to 40 mm long fry. These results suggest that during transport of spawn and fry, if the maximum oxygen level can possibly be maintained at 2 ppm in the medium, there is less chance of mortality within 100 and 250 ppm CO_2. Saha et al., (1956), however, observe that spawn can withstand dissolved CO_2 and dissolved free ammonia up to 20 ppm and 2.5 ppm respectively.

Spawn has been generally transported within and outside Bengal in earthen pots with water from the collection ground and a few grams of finely pulverized red soil sprinkled over the surface of the water. Periodic scraping of the bottom of the container, by means of a cloth rolled into the form of a rope, to throw out the bottom mud and occasional shaking of the entire medium during transit are a common sight. At intervals of four hours the water is changed and red soil added; the traders believe that without this there would be a heavy mortality. Basu (1951a) reported that these soil particles help in attracting the negatively charged spawn infected with bacteria to the bottom of the container and keep them buried under the soil, keeping pollution localized. In a series of experiments undertaken in the Technology Laboratory of the Directorate of Fisheries, West Bengal, on the mortality of spawn and fry of Indian major carps, it was proved beyond doubt that water

collected from spawn collection centres as a medium of transport had no specific effect; tank water being as good as the spawning ground water. Similarly, specificity of red soil also could not be established, ordinary soil in finely pulverized condition having the same effect. However, addition of pulverized soil, in general, increased the survival period, possibly due to the presence of some chemical ingredients needed for spawn (Saha and Chowdhury, 1956). Mortality occurred almost instantaneously in acid water, but by adjusting the pH to 8.5, spawn could be transported for about 56 hours by rail with only a three to four percent mortality. As earthen containers are liable to break, other containers of galvanised iron or tin were devised but transport in these involved constant care and attention of attendants who had to accompany the consignments. To avoid such difficulties experiments with closed containers were undertaken in the Orissa, Punjab and Madras Fisheries Departments to transport fish fry with and without oxygen packing. Mitra (1942) seems to be the first amongst the Indian workers who foresaw the possibilities of fry transport in closed containers with oxygen under pressure. Khan (1946) devised an oxygenated container for 30 to 200 fry and fingerlings (depending on their size). Raj and Cornelius (1949) successfully transported mirror carp fingerlings from Ootacamund to Kumaon (Uttar Pradesh) in an improvised 10 gallon petrol can with oxygen under pressure. Ganapati and Chacko (1951) made a comparative study by transporting C. chanos (5 to 8 cm), M. cephalus (2 to 8 cm) and E. suratensis (5 to 8 cm) in tin carriers with and without oxygen.

For successful transportation, concentrations of toxic substances like CO_2 and NH_3 should be kept low, or alternatively they should be removed as soon as formed. Srinivasan et al. (1955) studied the effect of secondary sodium phosphate at 1.5 g/l in the transportation of fingerlings of L. fimbriatus, C. reba, B. sarana, C. catla and C. mrigala in open and oxygen-filled containers. They concluded that replenishment of oxygen is the main problem; removal of CO_2 alone did not help in any way in the open containers, but it had a beneficial effect in closed containers where fry could be transported for 48 hours with 0 to 2 percent mortality. Saha et al. (1956) used permutit, activated charcoal, amberlit and pulverized earth at 2.5 parts/100 parts of water for the removal of carbon dioxide, ammonia and poisonous gases, and found that permutit was the worst absorbent as it removed dissolved oxygen also, though it removed the maximum of ammonia. Pulverized earth, and amberlit and charcoal were found to be effective for any transport up to 72 hours, and beyond 72 to 80 hours, respectively. In their experiments secondary sodium phosphate reduced the transport period by 24 hours in comparison to control, probably due to the sudden change of pH.

The credit for introducing polythene bags on an economic basis goes to the Department of Fisheries, Bombay, which successfully transported major carp fry 20 to 25 mm in size, from Calcutta to Bombay in 1955 in two polythene bags measuring 840 mm x 610 mm and having a thickness of 0.0625 mm placed in 18 litre empty kerosene oil tins and partially filled with water so as to take the shape of the container. After putting in the fry the bags were pressed to the level of water to expel the air. Oxygen from a cylinder was released slowly in each bag until it was blown up to the top of the tin container. The bags and tins were closed and put into cardboard cartons with pieces of paper in between the tin and inside of each carton to serve as insulation. In a 12 hour air journey, the mortality was 2.25 percent and 3.5 percent in the two bags which contained 1,200 and 2,300 fry respectively (Ranade and Kevalramani, 1956).

This method has come to stay as the only means of large-scale transport on an economic scale except that the cardboard cartons are not used now. Large consignments of carp fry are despatched every year to various destinations within the country by rail and air.

While carp fry can now be safely transported, transport of carp fingerlings (50 to 100 mm) is still a problem. Effective methods of transporting these have been developed in Madhya Pradesh in 40 gallon (180 litres) capacity galvanized iron drums. An opening 48 cm x 30 cm is cut along the main body of the cylindrical container through which fingerlings are introduced into it. To avoid rolling of the drum, four small iron brackets are fixed opposite to the opening on the outer surface of the body. A mortality of about 5 percent has been observed in such containers (Anon., 1955).

The transport of adult fishes, especially major carps is a problem confronting most fishery workers. Since these are generally required for breeding, it is essential that they are transported with the least shock and injury. The best equipment that is now recommended for this purpose is the splashless tank with attached aeration equipment developed by the Fisheries Extension Unit, Hyderabad (Mammen, 1962a). Open canvas containers (1 m x 1 m x $1\frac{1}{4}$ m) are already being used in Punjab and Madhya Pradesh for transporting major carp breeders.

Culture of salt-water fishes is not practised intensively in India. Estuarine mullets, prawns and pearl-spot are taken into the brackish-water bheris of West Bengal and paddy fields of Kerala along with tidal water. Unfortunately, no serious attempts were ever made to collect or segregate the fry of desirable species for stocking, hence any large-scale transport activity is lacking. Fry of M. tade, M. parsia, M. cephalus and M. corsula are collected from estuaries, coastal swamps and creeks for stocking the fresh-water ponds in coastal districts of West Bengal. Experiments conducted to transport them without mortality have shown that earthen hundies give better results than tin carriers, and that 200 fry (15 to 30 mm) per earthen hundi with 22 litres of water can be safely transported for a period of about four and a half hours (Sarojini, 1958).

The failure of Chanos culture in South India is adduced largely to difficulties in transporting the fry. The present practice consists of conditioning the fry in nurseries for 24 hours after collection and later acclimatizing them in tin carriers containing four buckets (28 litres) of sea water. By a process of removal of one bucket and addition of one bucket of fresh well-water, the salinity is reduced to nearly that of fresh water in a period of about 12 hours. When these fry, about 250 to 400 in number and ranging from 13 to 17 mm in size, are transported in a tin carrier, a mortality of 15 to 30 percent is usual after a six hour train journey. The Fisheries Extension Unit, Mandapam Camp (South India), has recently reported that as many as 150 fry could be transported in 175 cc of water for 24 hours without any mortality when packed in a small plastic bag, 20 cm long and 12 cm wide, with oxygen under slight pressure. The oxygen consumption of Chanos fry is calculated to be as low as 0.0002 cc per fry per hour (Mammen, 1962b). Dealwood boxes measuring ca. 55 cm x 32 cm x 33 cm were constructed with vertical and horizontal partitions to receive 40 such bags, thus transporting 6,000 fry at a time (Rao, 1961). Successful methods of transporting Chanos fingerlings may help in promoting its culture as their survival rate in ponds is not high now (Mammen, 1962b).

3.4 Eradication of aquatic weeds

The productivity of fish ponds is considerably reduced by infestation of weeds and obnoxious algal blooms. Various methods have been tried, but the problem has neither been tackled on a systematic basis, nor have the economics of the various measures adopted been considered seriously.

From smaller water bodies, clearance of weeds by manual labour is possible and economical too, but in larger and thickly infested ponds, tanks, bheels, jheels, etc., effective weed control can be achieved only by chemical, chemical-cum-manual, or mechanical-cum-manual clearance.

Amongst the floating weeds, water hyacinth (Eichhornia crassipes), is the greatest menace in the fishery waters of Bengal, Bihar, Orissa and Assam. While manual clearance is the most economical method for smaller ponds and tanks, treatment by the chemical weedicide 2,4-D, seems to be the best for larger bodies of water (Philipose, 1963; 1964; Ramachandran, 1963).

Common marginal weeds, Typha, Colocasia, Sagittaria, Cyperus, Scirpus, Juncus, Ipomoea and Jussiaea, and emergent weeds such as Trapa, Limnanthemum, lotus and lilies, can be controlled effectively by cutting the shoots under water repeatedly at intervals with hand scythes.

Generally, it is the submerged weeds, Hydrilla, Vallisneria, Nechamandra, Ottelia, Ceratophyllum, Najas, Utricularia, etc., which are the most obnoxious. Shading by floating weeds like Pistia, Salvinia, Azolla or Lemna, and production and maintenance of permanent algal blooms check these weeds effectively but these methods may not be practicable in larger expanses of waters or swamps. Here dragging metal chains or rakes, with the help of hand- mechanical-or power-driven winches may be useful (Mitra, 1956b).

Sodium arsenite at 4 to 6 ppm, depending upon the density of infestation, has been found to be the most effective and economical chemical treatment for submerged weeds. Although poisonous, it does not kill fish at this dosage but must be used carefully and cattle and human beings should not be allowed to use the water for drinking or any domestic purpose for about 10 to 15 days after treatment. However, two treatments per annum are sufficient. Addition of 10 ppm of copper sulphate after lowering the pH to 6.0 acts as a weedicide for Hydrilla and Chara, the vegetation completely decaying and settling to the bottom in about 25 days (Banerjea and Mitra, 1954; Mitra, 1959). Effective control of submerged weeds by using anhydrous ammonia according to a prescribed technique has been advocated by Ramachandran (1962). With 12 ppm of nitrogen, it is practically non-poisonous to livestock and can be used for sectional treatments and maximum concentrations easily achieved in the zones of thick infestations. Possibilities of biological control of weeds by stocking such ponds with grass carp (Ctenopharyngodon idella) are being explored.

Algal blooms can be controlled with 125 ppm of commercial sulphuric acid in 24 hours without affecting zooplankton (Khanna, 1960) and in neutral or slightly alkaline waters with 0.25 to 0.5 ppm of copper sulphate. Copper sulphate at 2 to 3 ppm in slightly alkaline waters or sodium arsenite at 3 to 5 ppm completely controls the filamentous algae.

The economics of the various methods adopted for controlling the weeds have been discussed by Philipose (1963) and Singh (1962) has found the possibility of utilizing aquatic weeds as composts for manuring agricultural fields. Yard experiments gave higher fruit yields with Najas, Hydrilla and Ottelia while Eichhornia compost gave consistently lower yields than the control (no treatment). Experiments are underway to evolve a suitable compost prepared by mixing different weeds according to their mineral contents.

3.5 Breeding of carps

As stated earlier, the collection and supply of quality fish seed to meet its increasing demand posed a problem in the expansion of fish culture activities. Attention was, therefore, paid to inducing the carps to breed in bundhs, by artificially flooding them as is practised in the Midnapore and Bankura Districts of West Bengal, and also breeding them by administration of pituitary gland extracts.

The factors inducing spawning of carps in rivers and bundhs were discussed at a symposium in 1945 and since then several workers have further studied the problem with a view to popularizing the practice of bundh-breeding in other parts of the country. Heavy rains, submerging partially or wholly, the shallow adjoining spawning grounds (Ganapati and Alikunhi, 1950; Ganapati et al., 1951; Khanna, 1958), low alkalinity (Saha et al., 1957), together with many other factors, like lunar periodicity, etc., were shown to stimulate the breeding of carps.

In Madhya Pradesh, special attention has been paid since 1949 to the study and location of spawning grounds in the riverine stretches and bundh type of tanks, and during the past decade to the construction of dry bundhs and the breeding of carps in these. The carps have been observed to breed in standing waters, over hard, stony, soft or clay substrata, with water temperatures ranging from 26° to 33°C and pH from 7.2 to 8.2 (Dubey and Tuli, 1961). Breeding in about 35 perennial tanks and reservoirs comparable to wet bunds has been established. The first successful experiment in dry bundh-breeding was carried out in 1958, and since then many more bundhs have been constructed by the Department and the farmers. The practice of dry bundh-breeding is to collect mature and maturing breeders from perennial reservoirs during May and June, keep the sexes segregated in small ponds till the first

monsoon showers; then to introduce selected numbers of these breeders, in the proportion of one female to two males, into the dry bundh as soon as sufficient water has accumulated there; then to wait and watch for their breeding. Eggs are collected with gamchha at the end of the spawning activity. Hatching hapas are ordinarily fixed in the breeding bundh itself. Studies on some of these bundhs by Alikunhi et al. (1964a) are of interest as breeding of carps has also been observed in ordinary ponds. These authors have reported repeated breeding in dry bundhs without removal of the water (unlike bundh-breeding in West Bengal) and made suggestions for improvements in bundh breeding by advocating new hatching techniques, removal of overgrowth of grass from spawning grounds to facilitate collection of eggs, removal of weed fishes to enhance survival, and better selection of breeders which are free from injuries and in healthy condition to ensure 100 percent breeding. They also suggest the fixing of hatching hapas in relatively clearer waters, where silt and oxygen would not be limiting factors, use of bleaching powder at 1 ppm for killing fairy shrimps (Streptocephalus and Branchinella) and, draining and refilling of ponds for subsequent breeding to avoid fairy shrimps and fry from earlier spawnings during collection. The selection or construction of a dry bundh has been described in which spawning grounds could be prepared in such a way as to flood them at different water levels for individuals of different sizes and species. Methods for achieving successful breeding on a commercial scale have been recommended.

Considerable experience in the construction of dry bundhs has been gained in Madhya Pradesh during recent years and while many existing bundhs have been improved, latest constructions are generally masonry structures with arrangements for overflow of excess water and complete draining of the bundhs. Apart from the bundh itself, a dry bundh unit now consists of storage ponds for breeders, an observation post with arrangements for storage of necessary equipment, and a set of cemented hatcheries with a regular supply of water for handling a very large number of eggs at a time.

Collection of spawn from rivers has manifold disadvantages. The collection centres being situated in remote, inaccessible areas and the period of spawn availability being short and dependent on various weather conditions, the resources are never exploited to the maximum advantage. Further, the rearing of river spawn being of a mixed quality, is uneconomic. Though bundhs do yield quality spawn, they are few in number and the production is limited compared with the demand. However, the need to induce the major carps to breed in confined waters was realized as far back as 1937, when Khan made an unsuccessful attempt to induce spawning in Cirrhina mrigala by injecting mammalian pituitary gland (Khan, 1938b). No further attempts were made till the mid-fifties when a number of experiments were simultaneously carried out in the Zoological Laboratory of the Mysore University and the Pond Culture Division of the Central Inland Fisheries Research Institute. Clarias magur and Heteropneutes fossilis, two air-breathing cat-fishes were successfully induced to spawn in the Mysore University (Ramaswami and Sunderaraj, 1956, 1957 a-c; Ramaswami and Lakshaman, 1959). Chaudhuri (1960) successfully bred the carp minnow, Esomus danricus, and the catfish, Pseudotropius atherinoides, by intraperitoneal injection of carp pituitary gland in 1955 and 1956 respectively.

During the 1957 breeding season, the major carps, Labeo rohita, Cirrhinus mrigala and Labeo calbasu, and the medium-sized carps, Cirrhinus reba, Labeo bata and Puntius sarana were for the first time successfully induced to breed by pituitary treatment at the Central Inland Fisheries Research Sub-Station at Cuttack, Orissa (Chaudhuri and Alikunhi, 1957). During these experiments both intraperitoneal and intramuscular injections were successfully tried and the fish bred in clear tap water, accumulated rain water and stagnant pond-water, some six to eight hours after injection. However, in certain instances a second injection at an interval of eight to ten hours was necessary. It is significant to note that only fish pituitary glands were used, and that intramuscular injections required a much smaller dose than the intraperitoneal. In the majority of cases of successful spawning, fertilization was almost hundred percent and hatching as high as 95 percent. It was noted that the doses depended on the size and stage of maturity of the gonads of the breeders. However, the determination of dosage was still not well developed. Further experiments were continued at the Cuttack Sub-Station to determine the dosages and standardize the technique. Mammen and Sulochanan (1962) and Badami and David (1964) successfully bred catla

at Mettur and Tungabhadra reservoirs respectively. The Fish Breeding Centre established at the farm below the reservoir by the Tungabhadra Fisheries Board is undertaking extensive induced breeding work on Indian major carps, particularly catla, which clearly indicates that this work can very well be done successfully at other centres. Chaudhuri (1964) has outlined the methods followed in inducing spawning of Indian major carps by pituitary injection. Suggestions have been made to use homoplastic pituitary glands removed from live or recently-killed fishes or from fishes well-preserved in ice. Simple methods to remove the gland, by removing the top of the cranium or by cutting the head longitudinally into two equal halves, have been described. Techniques of preservation, preferably in alcohol, preparation of gland suspension and injection, calculation of dosages, etc., have been discussed in detail. An initial dose of 2 to 3 mg/kg of body weight to the female fish, followed by a second injection at 5 to 8 mg/kg of body weight after 5 to 6 hours, together with a dose of 2 to 3 mg/kg of body weight to the males (generally two in number for each female), gave highly successful results. Earlier, Chaudhuri (1959) had already described the methods of distinguishing the sex of breeders of Indian major carps. Great stress was, however, laid during all these years on temperature range and for successful results optimum temperatures were considered to vary between 74° to 87°F (23.3° to 30.6°C).

The two Chinese carps, Ctenopharyngodon idella and Hypophthalmichthys molitrix, introduced lately into India were also successfully induced to breed for the first time in ponds at the Cuttack Sub-Station during July 1962 when these were just three years old (Alikunhi et al., 1962, 1963). The techniques of breeding adopted were essentially the same as those followed in the case of Indian carps but due to the limited stock of breeders of the two species and also the need to arrive at the correct dosages, the injected fish, as soon as they started spawning, were taken out, stripped and the eggs artificially fertilized. However, the response of the Chinese carps to pituitary injections is identical with that of the Indian carps. The fecundity of C. idella compares with that of C. catla and of H. molitrix with that of C. mrigala. The induced-bred, pond-reared silver carp, H. molitrix, attained sexual maturity when only about one year old, and could be bred successfully by pituitary extract injections (Alikunhi et al., 1965).

The breeding season of the Indian major carps is short, and optimum weather conditions, such as cool, rainy days with relatively low temperatures, are limited to a very few days during this period, so the scope of induced breeding is very much restricted, even when a good stock of breeders is available. It is therefore obvious that if suitable weather conditions are provided, breeding could be induced almost every day during the monsoon months. Alikunhi et al. (1964b) have made preliminary observations on commercial breeding of Indian carps at controlled temperatures in an air-conditioned laboratory. As eggs produced in the air-conditioned laboratory did not hatch satisfactorily under field conditions, it was considered necessary to hatch the eggs also under laboratory conditions.

Further results have been achieved during the past years. The interval between the first and the second injection has been reduced to three to four hours, instead of the usual six hours, with satisfactory results. Fish have been made to spawn even at 38°C, but the fertilization, hatching and survival to fry stage in this case was very poor. Fishes were induced to breed in Assam as early as April, as they were ripe by the end of March. Studies on the effect of synthetic hormones on the gonads and spawning of fish are being conducted. Studies on the storage of fish sperm at low temperatures in different diluents showed that Cyprinus carpio sperm remained alive and active even after 72 hours at 0°C when kept in Frog Ringer's and Holtfreter's solution with 1 percent glycerine, but they died after 50 hours when the temperature was maintained at 9°C. Similarly sperms of L. rohita survived for 21 and 50 hours respectively when kept in the above diluents at 0°C. Experiments on the effects of feeding vitamin E (Ephynal) on the gonadial maturity of fishes indicated a slightly better growth, maturity and slightly higher average weight of ovary per gram body weight of treated fishes over controls. The effect of Rontgen rays on the eggs and fry of C. carpio and their further development is under study (Barrackpore, 1965).

To disseminate the knowledge gained at the Cuttack Sub-Station in the induced breeding of carps, brief training courses for the State Fisheries Officers and the Fisheries Extension Officers have been conducted almost regularly from 1958 onwards. Reports have been received

regarding the success in such experiments from Orissa, Andhra Pradesh, Madhya Pradesh and Uttar Pradesh. For the last two years, the Pond Culture Division has provided technical assistance to establish fish breeding centres in various states. This Division is also distributing fry of the major carps and common carp to deficit states in India for introduction into various waters; it is also distributing Chinese carp fry to all the states for studies on rearing and growth in the different environments.

Research work in the Indian Universities and elsewhere on the structure of the pituitary gland of different species has further helped to understand the physiology of breeding (Das and Khan, 1962; Ramaswami, 1962; Lal, 1964). Success in induced breeding has opened up a new line for research, that of producing different strains of fish with better qualities of flesh and growth. Hybrids produced by crossing indigenous fishes are being reared at Cuttack, and it has been observed that the hybrid of rohu-catla grows better than catla, and that catla grows better than the hybrid of Labeo fimbriatus and Catla catla (Barrackpore, 1964). Much more work is required along these lines.

3.6 Culture of exotic fishes

The first exotic food fish to be introduced after Independence was the controversial Tilapia mossambica, which was brought to India almost simultaneously by the Madras Fisheries Department and the Central Marine Fisheries Research Institute in 1952. It soon became popular in the South and was introduced into a large number of ponds, tanks and even reservoirs in Kerala. However, it was soon found that the population in ponds was stunting. Experiments in the Pond Culture Division at Cuttack proved that tilapia is a predatory fish in nursery ponds and competes seriously with mrigal, and to some extent with rohu, in the stocking ponds, affecting their growth. It is, therefore, not considered to be a compatible species for culture with carps. Experiments to culture tilapia males alone in stock ponds have also not yielded very encouraging results, as a few females inadvertently gained entry into these ponds and spoiled the experiments. Culture of tilapia along with murrels gave some encouraging results and the work regarding the size and ratio of fingerlings and fish to be stocked is in progress. With heavy manuring and artificial feeding, repeated netting of tilapia ponds has yielded 5,780 kg/ha/annum.

The Prussian strain of Cyprinus carpio introduced into the Nilgiris did not breed successfully in the plains, hence another strain of this species was brought to India in 1957 from Bangkok. This strain bred freely in the plains where the temperatures were considerably higher than on the hills. However, in recent years even the Prussian strain, Cyprinus carpio var. specularis (mirror carp), has been acclimatized and now breeds freely at various places in the plains in India. Mirror carp were transplanted from the Nilgiris to Kumaon (1947), thence to Himachal Pradesh (1955), Kashmir (1956), Sikkim (1957), Punjab (1958), Madhya Pradesh (1959), Bihar (1960) and Rajasthan (1960). With the introduction of mirror carp to Himachal Pradesh, this area has not only become self-sufficient in fish production, but a leading state in supplying young fish for stocking to other states. This State has now undertaken the stocking of Gobind Sagar Lake (Bhakra reservoir) with mirror carp juveniles from the Deoli Fish Farm (Anon., 1962a). A large number of lakes in Kashmir sustain a crop of mirror carp, which is sold in markets as a coarse fish.

In the plains there is still a great shortage of carp seed, hence culture of common carp has been suggested. Common carp fry have been distributed by the Cuttack Sub-Station to various states where many articles have been written and pamphlets distributed to popularize this new fish. Simple techniques have been developed at Cuttack to breed the common carp in cloth hapas on a commercial scale, giving up the use of kakabans and cement cisterns. Such hints have been outlined by Alikunhi (1960) and circulated to all state governments. Studies on the fecundity, hatching, rearing and growth of the fish have been made. Under Indian conditions, this species is reported to grow faster than mrigal and rohu, and almost as well as catla, but in terms of weight its production equals the combined production of rohu and mrigal.

The common carp attains maturity when it is 15 to 20 cm long and six to eight months old; it lays about 130,000 to 230,000 eggs/kg of body weight. Unlike in temperate countries,

it breeds in the plains of India almost throughout the year with peak periods from mid-January to the end of March, and during July-August. Breeding is either limited, or there is almost no breeding, when the temperature goes very high during summer or very low during winter; however, the same fish can be made to breed three or four times in a year at an interval of two or three months. Hydrilla or Naias have been found to serve as suitable egg-collectors and are introduced into hapas in the proportion of twice the weight of the female fish. The period of incubation ranges from 36 to 72 hours depending upon the prevailing temperature and the fry are ready for stocking on the fourth or fifth day after spawning. Common carp attains an average weight of about a kilogram in a year. Various combinations of common carp with indigenous and exotic carps are being tried to find the best ratio in which these could be stocked in ponds.

In order to increase the variety of quick-growing cultivable species of fish, and to conduct observations on the use of grass carp for controlling rapid growth of weeds in tropical warm water ponds, experimental consignments of fingerlings of silver carp and grass carp were brought to India for the first time in 1959 (Alikunhi and Sukumaran, 1964). The carp have not only been induced to breed in India, but also used for culture in view of their remarkable growth and biological utility in Indian conditions. Observations on their feeding habits have shown that the silver carp is predominantly a phytoplankton feeder, while the grass carp feeds avidly on Hydrilla, Lemna, Azolla, etc. Ponds where silver carp and catla were stocked together recorded less production than ponds where silver carp were grown alone, but a little more than where catla alone were reared. This proves silver carp to be a superior fish to catla in regard to growth, and is also otherwise preferred to catla as it is less bony and more tasty. Grass carp, stocked at the rate of 50 to 60 fish weighing 70 to 90 kg per acre (=0.405 ha), were found to utilize duck-weeds at the rate of about 2 kg/fish/day. Unlike in China, silver carp, both males and females, attained maturity in India when about two years old, 54 cm long and about 1.8 to 2.4 kg in weight. Though grass carp males matured at about the same age, size and weight as the silver carp, the females did not (Alikunhi et al. 1965). Since 1962, stocks of these carps have been built up by induced breeding at Cuttack for further studies, and they have also been distributed to almost all the states of the Indian Union for experiment and propagation.

3.7 Brackish-water fish culture

As about 2,000 square miles of culturable coastal tracts are available in India, there is vast scope for the development of brackish-water fish culture on a commercial scale (Panikkar, 1952). Attempts in Madras and Kerala have yielded a good deal of information and have been a step towards organizing the industry on scientific lines, and more attention is now being paid to brackish-water culture possibilities. The existing practice of fish culture in the deltaic areas of West Bengal is part of a slow process of reclamation of the land for conversion into rice-fields; this has been described by Pillay (1958) and Pakrasi et al. (1964). However, the industry is still backward and much research work is needed to make fullest use of these water bodies. The Central Marine Fisheries Research Institute, Mandapam Camp, also undertook the study of the growth of Chanos in an experimental farm constructed there for the purpose.

Pillay (1954) outlined suggestions for the improvement of the bheri culture of Bengal. Unsatisfactory water supply due to greatly diminished tidal range, inadequate and haphazard stocking, no attempts at the removal of predators, lack of food production and the limited period of growth, are some of the causes responsible for the low production from bheris. To increase production, it is necessary to prevent predatory and uneconomic varieties of fishes gaining entry into these ponds, and to fertilize them to grow more fish food. Experimental studies have been made to determine the growth requirements of blue-green algae (Pillai, 1954; Bose, 1960), the effects of salinity on nitrogen transformation (Mandal, 1962a), and the type of fertilizer for brackish-water soils (Mandal, 1962b).

Ecological studies of brackish-water bheris (Pillay, 1954; Pillay, Vijayaraghavan and Thakurta, 1962) have been very useful for understanding the biotic interaction. Each species of alga has been found to have its own salinity and water-depth preferences; higher water

temperatures and salinity are conducive to greater production of benthic algae, and soil nutrients appear to be of greater significance than the nutrients in the water for the production of the benthic flora.

Ecological studies of some of the tidal lagoons, with a view to finding their suitability for development into salt-water fish farms, as well as the construction requirements, selection of species, production of food, and supplementary feeding in Chanos culture, have been discussed by Tampi (1959; 1960).

The Brackish-water Fish Culture Section of the Central Inland Fisheries Research Institute, have located suitable grounds and methods of collection. Shooting nets and hapa nets are now being introduced for collecting the fry. Fry of bhetki (Lates calcarifer) are available during May to October in Thakuran and Matlah rivers; M. parsia in Muriganga, Matlah, Thakuran and Saptamukhi rivers almost throughout the year; M. tade during September-October in and around Kakdwip; and M. corsula during July to October. Preliminary investigations on the culture of mullets and Chanos were initiated in the brackish-water farm at Keshpur, near Chilka, and a remarkable growth of M. cephalus, M. troschelli and Chanos chanos, observed.

3.8 Fish culture in rice fields

The use of paddy fields for carp culture was suggested by Hora and others, and certain preliminary experiments were made (Hora, 1943 g, h, 1951; Chacko and Ganapati, 1952; Iyengar, 1953). However, experiments conducted in Bihar, Uttar Pradesh and Andhra Pradesh in recent years have not given significant results. Experiments conducted at the Indian Rice Research Institute's plots at Cuttack between 1957 and 1960 by the Pond Culture Division have indicated that there is not much scope for this work in India, particularly where there are no irrigation facilities or the fields are liable to flooding.

3.9 Sewage fish farming

Utilization of sewage for fish cultural purposes have been considered since the Symposium of 1944, though no serious attempts were made to investigate the problems. However, Ganapati and Chacko (1950) suggested the construction of a sewage fish farm, while Saha et al., (1958) studied the physico-chemical properties of Calcutta sewage in relation to its use in sewage-fed bheris, and suggested dilution of raw sewage with fresh water to bring down the concentration of inimical ingredients below lethal limits before introduction into a fishery. Gopalakrishnan and Srinath (1963) suggested the use of treated domestic sewage (activated sludge) as a fertilizer for fish ponds in view of its easy transportation in the dried form and storage for use at the farm whenever necessary. Laboratory experiments to determine the effect of sludge on growth of fingerlings of C. carpio, C. mrigala, C. catla indicated that the sludge has a direct influence on increasing the growth of fish and production of plankton due to the release of nutrients into the water. The sludge had a more pronounced effect on the growth of mrigal, which may be due to their habit of consuming more of the decaying organic matter from the bottom.

3.10 Prawn culture

Interest in prawn culture in fresh-water ponds has developed only recently. Experimental consignments of Macrobrachium rosenbergii and M. malcolmsonii were collected from Godavari and transported from Rajahmundry to Hospet (Tungabhadra Dam) and Cuttack. The prawns stocked in the ponds at Cuttack in the nurseries grew well and bred. Juveniles of M. malcolmsonii have been stocked in various tanks and reservoirs of Mysore State during January-February, 1965, and their growth rate, etc., are being studied. Attempts to breed M. rosenbergii in the laboratories of Central Inland Fisheries Research Institute, Barrackpore, were successful and during the course of this work, various interesting observations on the breeding behaviour were also made (Rao, 1964).

The paddy fields bordering the Vembanad Lake in Kerala and those situated alongside the tidal rivers in the Sunderban area of West Bengal are used extensively for the cultivation of prawns for some period during the year. The prawn fry, along with certain other species of fish, are impounded in these fields which are converted into vast enclosures with masonry sluicegates (Menon, 1954; Gopinath, 1955; Panikkar and Menon, 1955; Pillay and Bose, 1957; Pillay, 1958). These methods of prawn culture are far from intensive, and there is much scope for improvement. Suggestions to culture prawns on scientific lines by selective stocking, manuring of ponds, extension of rearing periods, etc., have been made by these authors, but nothing has been done so far in the field to achieve greater production.

3.11 Public health and fish culture

Except for a few studies on the habits of Gambusia affinis (Chacko, 1948), Aplocheilus lineatum (Chacko and Ganapati, 1949a) and larvicidal propensities of Carassius auratus Chacko and Ganapati, 1949b), no further work was done on the larvicides. Some state governments, however, did continue to collect and distribute larvicides and cyclopscides to the Blocks and Panchayats to control filariasis and guineaworm.

3.12 Culture of predatory fishes

Culture of murrels (Ophiocephalus spp.),though started in Madras at Sunkesula (Nicholson, 1918) and at Madhopur in Punjab in 1917 never became important. The culture of pangas catfish, Pangasius pangasius, for the control of molluscs (Hora, 1952, 1953) has been suggested, but without any scientific background with regard to suitable sizes for stocking, timings of stocking, and any information on the forage-predatory fish ratio. Some preliminary experiments with tilapia as a forage fish for Channa (Ophiocephalus) striatus were, however, carried out, but no large-scale murrel culture can be advocated at present in view of the scarcity of knowledge.

3.13 Fish diseases and mortality

Khan (1944) made some observations on the parasitic diseases of carps in ponds and suggested definite treatments. Considerable work has been done on the control and prevention of parasitic diseases in ponds in recent years. The symptoms and control measures for diseases caused by Ichthyophthirius multifilis Gyrodactylus sp., Argulus spp., Isoparorchis hypselobagri, Ligula sp., and Saprolegnia parasitica have been discussed by Gopalakrishnan (1964) in a Symposium held under the auspices of the Zoological Society of Calcutta on Recent Advances in Parasitology. Biological methods for the control of Ligula and Isoparorchis hypselobagri have been suggested.

Fish mortality in ponds and tanks has been recorded by various workers. A common practice to prevent sudden mortality in fish ponds followed by fish farmers in Bengal is to cut banana plants into pieces and float them over the ponds, or crush and extract the plant's juice and mix it with pond water. Basu (1958) investigated the problem with a view to understanding the basic scientific principles involved, and found that though the juice had an acid pH (5.2 to 5.7), it contained considerable amounts of methyl orange alkalinity. The addition of the juice thus lowers the pH of the water slightly but considerably increases its buffering capacity, preventing mortality due to increased concentration of carbon dioxide.

4 CONCLUSIONS

Apathy of the public, lack of financial patronage and shortage of trained personnel, are some of the chief reasons for the backward condition of piscicultural programs in the country in spite of the existence of Fisheries Departments in many states. Only relatively recently has public attention been drawn to fisheries development and pond culture came to be recognized as a relatively easy and quick means of increasing food supplies. Various State Fisheries Departments have organized extension services through which technical and financial help is given to the farmers to improve existing fish culture techniques, and to bring unused areas under cultivation. Reclamation of derelict ponds and tanks was undertaken by cooperative societies organized for the purpose, thus adding greatly to the area of water under pisci-culture. 'Demonstration fish farms' to impart knowledge concerning improved methods of fish

culture, 'nursery farms' or 'fish seed farms' to supply quality fish seed in remote areas at nominal rates, and 'experimental or research farms' to study problems of local interest, have been established throughout the country. Exhibitions are arranged on various occasions and propaganda and publicity conducted during such occasions have given a great impetus to fish culture programs, as individual fishermen and cooperative organizations constantly come forward for further government help.

The paucity of trained personnel for implementation of fish culture programs was met by initiating training courses at selected centres. A training section was established at the Central Inland Fisheries Research Institute in 1948 where a ten months' course of instruction in inland fisheries with special emphasis on fish culture was organized which has now been raised to a twelve months' course. During the last 17 years 380 candidates have been trained at this Institute, including 17 under the Colombo Plan. The eighteenth session of the training course with 44 candidates, including three foreigners, is at present in progress. Training centres have also been established in the states as well to impart short-term training, generally six months, to undergraduates for manning subordinate services. Occasionally, short-term training courses are arranged for block development officers and village level workers. The lack of text-books presented great difficulties to the teaching of fish culture. The situation was helped by Rao and Prasad (1953) and Rao (1963), who compiled the existing information on inland fisheries and oceanography.

With the establishment of the Central Inland Fisheries Research Institute and the availability of experimental data to effect improvements in fish cultural practices, it was found necessary to build up an agency to ensure the proper application of these results in the field. A Central Fisheries Extension Service, with the object of functioning as a liaison between the research laboratories on the one hand, and the fisheries departments and the fishermen and fish farmers on the other, was established by the Government of India in 1953; this has since expanded and now covers almost all the states. The extension units distribute suitable pamphlets, guide the fish farmers on methods of scientifc fish culture, and arrange exhibitions and film shows with the idea of educating the public.

In 1959, the National Development Council stressed the need for assisting village communities in building up community assets such as fish ponds and other inland waters, which indirectly meant utilization of man-power resources. The role of panchayats (village councils) in certain other functions, such as regulation of collection of fish spawn, cannot be over-emphasized. The annual conferences on community development held at Mysore and Srinagar in 1959 and 1960 respectively, and also the working group on panchayats, recommended that the task of fish culture in village tanks should be entrusted to panchayats, which should be entitled to make use of the income from fisheries. This has further helped the expansion of fish culture activity. In fact, in Orissa and Andhra Pradesh good progress has been made by panchayats in undertaking fish culture in tanks owned by them.

The figures of actual production of fish from cultured waters are not available, but the magnitude of the production can be roughly estimated from the fact that 267 million carp fry and fingerlings and 1,400 million spawn were collected and 0.947 million acres (0.3841 million ha) of water stocked with them during the First Five Year Plan (1951-56), and during the Second Five Year Plan (1956-61) the production of fry and fingerlings for stocking tanks and ponds rose to 1,800 million (Anon., 1962b).

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I/RR-2

POSIBILIDADES DE LA PISCICULTURA EN ESTANQUES EN AMERICA LATINA

por

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Extracto

La experiencia personal del autor como oficial regional de la FAO, confirmada por la respuesta de los Gobiernos al cuestionario circulado, indica que la piscicultura en estanques en la escala encontrada en otras regiones, practicamente no existe en la América Latina. Se analizan las actividades más o menos esporádicas, piscícolas, país por país, se da información sobre las especies, y se trata de examinar algunas de las razones que pueden existir para esta aparente carencia general de interés, con algunas sugerencias para el fomento de la piscicultura como contribución al cuadro alimenticio.

THE OUTLOOK FOR FISH CULTURE IN WARM-WATER PONDS IN LATIN AMERICA

Abstract

Extensive personal experience of the writer in Latin America, confirmed by the information obtained through governments' replies to the questionnaire circulated preparatory to this meeting, indicate that there is virtually no commercial fish culture tradition in the Region comparable to that existing in other areas. An analysis is given, country by country, and by species, of the sporadic attempts which have so far been made, and some reasons are advanced for the lack of interest in fish culture in the Region.

LES PERSPECTIVES DE LA PISCICULTURE EN ETANG A TEMPERATURE ELEVEE EN AMERIQUE LATINE

Résumé

Une longue expérience personnelle de l'auteur en Amérique latine, corroborée par les renseignements recueillis dans des questionnaires envoyés aux gouvernements pour préparer cette réunion, indique qu'il n'existe, dans cette région, pratiquement aucune tradition de pisciculture commerciale comparable à celle que l'on trouve dans d'autres parties du monde.

L'auteur présente une analyse, par pays et par espèce, des efforts sporadiques qui ont été effectués jusqu'à présent et il propose certaines raisons pour expliquer le manque d'intérêt suscité par la pisciculture dans la région.

I/RR-2

1 INTRODUCCION

En contraste con la experiencia en los demás continentes - en algunos casos de muy antigua tradición (Asia), en otros de introdución reciente (Africa), en la América Latina la piscicultura en estanques en escala comercial "aún representa una actividad de menor importancia, y la costumbre de combinar el cultivo de peces con el de las cosechas agrícolas es desconocida"[1/]

Esta situación es a primera vista sorprendente, tomando en cuenta las grandes deficiencias dietéticas en esta vasta región, pero es necesario darnos cuenta de ella, con el fin de averiguar si los obstáculos son reales o superables. Las condiciones locales determinarán en cada caso si se justifica o no la implantación de sistemas de piscicultura que han tenido éxito en otras regiones.

La falta de una tradición de piscicultura, ya constatada por observación personal, se ha confirmado recientemente mediante una encuesta realizada por la Dirección de Pesca de la FAO entre los gobiernos asociados. Los resultados de este estudio, hasta donde se ha podido constatar actividad alguna en este campo, se resumen en el Cuadro I.

2 ZONA NORTEAMERICANA

Este informe comprende únicamante los países ibéricos de América. La situación reinante en la franja de los Estados Unidos donde las condiciones climáticas son favorables al cultivo de peces en agua templada, será tratada por colaboradores de ese país.

En México, donde el gobierno ha demostrado un vivo interés en la producción de peces en los depósitos de agua dulce, no menos de tres Secretarías de Estado adelantan sendas campañas en este campo. En estas circunstancias es inevitable cierta duplicación de esfuerzo, pero el resultado total es prometedor.

La Dirección General de Piscicultura Agrícola de la Secretaría de Agricultura y Ganadería, estima que la producción, (principalmente de carpas originarias de Israel) en casi 14.000 pequeños depósitos de agua, con una superficie total de unas 12.650 hectáreas, ha aumentado de 1.200 toneladas en 1960 a más de 9.000 toneladas en 1964 (véase cuadro II).

Se hace hincapié en que hasta ahora los trabajos piscícolas en México se refieren principalmente a la distribución de las crías procedentes de las estaciones que mantienen las tres Secretarías mencionadas, en embalses, represas, y otros pequeños depósitos de agua. La producción se consume en su mayor parte localmente, sin que se haya organizado una piscicultura intensiva de carácter comercial.

La Dirección General de Pesca e Industrias Conexas de la Secretaría de Industria y Comercio indica que, independientemente de las cifras arriba mencionadas, se ha logrado el cultivo de Pescado Blanco (Chirostoma sp.) en las cercanías del lago de Pátzcuaro, y que se ha procedido a la introducción de tres especies de Tilapia, en estanques especialmente construídos en Oaxaca, sin que hasta ahora haya habido una producción comercial, aunque demuestran una alta tasa de crecimiento, hasta de 30 cm. en 10 meses.

Los planes actuales incluyen no solamente el aumento de la productividad de los grandes embalses (unos 200 de grandes dimensiones y muchos más de pequeña irrigación), en colaboración con una oficina de la Secretaría de Recursos Hidráulicos sino también el enérgico desarrollo de la construcción de estanques para peces, con el objeto de crear una actividad económicamente atractiva, con costos y beneficios razonables y una mayor produc-

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1/ Memoria de la FAO ante la Conferencia de UNICEF sobre los Niños y la Juventud en la Planeación y Desarrollo Nacional en la América Latina, Santiago, Diciembre, 1965.

Cuadro I

Países que han informado sobre el cultivo de peces en aguas templadas
(Datos de 1964)

	Número de granjas con estanques	Número de estanques (est.)	Superficie en Hectáreas (est.)	Producción en tons. (est.)	Miles de jaramugos distribuídos	Observaciones
Bolivia	-	-	-	-	0.1	Carpa
Colombia	-	100	20	-	10.1	
Ecuador	1	-	-	1	-	(Black Bass)
El Salvador	200	288	12	-	40.0	
Guayana inglesa	-	442	57	-	23.0	(Tilapia)
México	4,380	14,000	12,650	9,026	15,000.0	(Véase cuadro II)
Puerto Rico	290	350	135	25	17.0	
Uruguay	-	-	-	-	10.0	

- No hay datos.

Cuadro II

Datos suministrados por el Gobierno de México
(Secretaría de Agricultura y Ganadería,
Dirección General de Piscicultura Agrícola)

	1960	1961	1962	1963	1964
Núm. de granjas con estanques	883	990	1,075	2,418	4,380
Núm.de estanques	1,019	1,250	4,330	8,480	13,650
Arrozales con peces	2	-	1	-	-
Producción estimada en tons.:					
Carpa	1,213	1,915	3.435	5,790	9.006
Black Bass	5	14	-	3	6
Bluegill	-	15	-	7	1
Bagre	-	-	-	2	10
Jaramugos distribuídos - miles					
Carpa	2,022	3,192	5,725	9,650	15,011
Black Bass	25	70	-	16	3
Bluegill	-	91	-	46	9
Bagre	-	-	-	5	25

ción por hectárea. En la actualidad las únicas granjas piscícolas comerciales existentes son dos o tres en Puebla y otros lugares en el Estado de México, que se dedican exclusivamente a la cría de truchas para restaurantes, siendo el producto fuera del alcance de los sectores de ingresos reducidos.

No obstante, entre los antecedentes más interesantes de la Piscicultura en México, nos encontramos con lo que nos brinda el pueblo de Acambay, en el Estado de México, donde desde tiempo inmemorial se realiza una rotación entre los cultivos agrícolas y piscícolas.

Los terrenos de estas zonas tienen bordes y un drenaje bastante primitivo pero eficiente, lo que permite manejar cada estanque en forma individual. La especie que tradicionalmente han cultivado es la carpa común, cuyos reproductores capturan en las presas próximas.

A partir de 1966, la Dirección General de Pesca pretende distribuir en esta zona una cantidad de jaramugos de carpa seleccionada de Israel y al mismo tiempo proporcionar orientación técnica en cuanto a la alimentación de los peces y el abonamiento de los estanques. Se tiene bajo observación en Tezontepec (Hidalgo) algunos ejemplares de carpa herbívora proveniente de la China. Se contempla una eventual colaboración entre las distintas dependencias oficiales que intervienen en el campo de la piscicultura.

3 ZONA CENTROAMERICANA

Tres gobiernos del istmo solicitaron los servicios de un experto de la FAO en piscicultura y durante los años 1955 a 1963 el Sr. S.Y. Lin (China) dividió su tiempo entre las Repúblicas de El Salvador, Guatemala, y Honduras. En cada uno de estos países se construyó una Estación Central de Piscicultura e Investigaciones Piscícolas, así como los correspondientes estanques en número suficiente para producir cantidades regulares de jaramugos de los peces más apropiados a ser cultivados en la región. También se concedieron becas para que varios funcionarios nacionales pudiesen estudiar piscicultura en el extranjero. Uno de estos becarios, el Sr. Mario Saavedra se ha reincorporado recientemente a su trabajo en Guatemala y está elaborando activamente un programa de piscicultura. No hay noticias recientes en cuanto a las actividades de los demás becarios se refiere.

Como es sabido, dos grupos importantes de peces, los Cíclidos (del grupo de las percas) y los Carácidos (familia Characidae) son abundantes en Africa y la América tropical, pero ausentes de otros continentes, salvo excepciones sin importancia. Varias especies africanas del primer grupo, pertenecientes al género Tilapia, han llegado a ser universalmente cultivadas durante los últimos treinta años, y se abrigaba la esperanza que entre los representantes americanos de la familia Cichlidae, que en su ambiente natural en Centroamérica y Venezuela alcanzan tamaños muy superiores a los ejemplares africanos, se encontrara el pez perfecto para una piscicultura indígena, sin recurrir a introducciones exóticas.

Se escogieron 17 especies centroamericanas para el estudio de sus características de tamaño, hábitos alimentarios, calidad de la carne, ritmo de crecimiento, capacidad de desove en el cautiverio, y la posibilidad de recoger cantidades de jaramugos en aguas naturales. Aunque estas investigaciones no deben considerarse agotadas, las pruebas indicaron que ninguno de estos peces reunía todas las condiciones necesarias. Por ejemplo, los Cíclidos que crecen a tamaños mayores son: el Lagunero (Cichlasoma dovii); el Guapote Tigre (C. managüense - ambos de los lagos nicaragüenses y la Istatagua (C. motagüense) que habita en los ríos y lagos de Guatemala, El Salvador, y Honduras. A pesar de encontrarse en su ambiente natural, ejemplares de uno y medio y hasta de dos Kilos, no resultaron aptos para el cultivo en estanques, debido a sus hábitos voraces y la imposibilidad de alimentarlos. Su crecimiento, por lo tanto, era lento y su reproducción difícil o imposible sin recurrir a métodos artificiales de poca aplicación en condiciones rurales.

Otros peces del género Cichlasoma que son vegetarianos o omnívoros, parecían a primera vista ofrecer mejores perspectivas. En efecto, la Caracara (C. trimaculatum) a veces se mantiene en estanques en las granjas de El Salvador. Sin embargo, tampoco dieron resultados satisfactorios porque a pesar de haberse encontrado ejemplares de 800 gr. (de 650 y 400 gr. tratándose de otras especies, entre ellas la Mojarra Negra (C. macracanthus) y la Mojarra Azul de Amatitlán (C. guttulatum)), la gran mayoría de los ejemplares son pequeños y su tasa de crecimiento en estanques era insuficiente para una piscicultura económicamente viable.

También dieron resultados negativos la Pepesca (Astyanax fasciatus), el Sábalo (Brycon guatemalensis) ambos de la familia Characidae, el Juilín (Rhamdia guatemalensis), y varios Cíclidos menores.

Habiéndose eliminado todas las especies nativas potencialmente cultivadas, se procedió a examinar las ventajas y desventajas de las introducciones exóticas, que ciertamente han sido objeto de serias diferencias de opinión.

Sea como fuera, no fué el experto de la FAO quién introdujo las especies sobre las que decidió trabajar en las aguas de Centro América, ya que la Carpa común escamosa fué introducida en Guatemala en 1926 por el Sr. Herman Cartens, mientras que la lubina (black bass) fué importada en Guatemala por el Sr. León Lind Pettersen en 1954, lo mismo que el Bluegill, (Lepomis macrochirus).

A pesar de la creencia que la Carpa tiende a dominar los ambientes donde se introduce, las que se introdujeron en aguas libres de Centro América se han capturado rara vez y la mayoría han desaparecido completamente, aunque todavía se conservaban algunos ejemplares en estanques. Por lo tanto, no siendo la carpa escamosa la mejor variedad para la cría en estanques, se introdujo en Guatemala, en 1956, una variedad seleccionada en Israel de Carpa de Espejo, y más recientemente se ha introducido en El Salvador y Honduras.

Existe la misma creencia tratándose de las Tilapias. Sin embargo, después de haberse introducido en Centro América en 1960, aclimatándose en un estanque de la Estación de Bárcenas (Guatemala) el hecho es que sólo sobrevivió en estanques o en aguas naturales poco profundas donde antes no existían peces nativos útiles. Más aún, la introducción de Tilapia mossambica fracasó en tres lagos de América Central (Amatitlán, Ilopango y Guija), mientras que la introducción de Guapote tigre (Cichlasoma managüense) en Ilopango en 1960 dió lugar a que, en 1962, éste era el pez más importante del lago, con capturas constantes de importantes cantidades. La introducción de la Lubina (black bass) en el lago de Atitlán en junio de 1959 dió, en cambio, lugar a su florecimiento en una pesquería excelente en 1961 y 1962, lo que representó la mejor producción en toda la historia del lago, pero últimamente la pesca ha disminuído de nuevo.

En el Cuadro III se demuestra el crecimiento comparativo de varias especies cultivadas experimentalmente en estanques en Guatemala.

Sea como fuera el argumento sobre las ventajas y desventajas de las introducciones de peces no indígenas, estas cifras son elocuentes en lo que concierne la piscicultura en estanques. Como resultado de estos experimentos, fueron sembrados con peces varios centenares de depósitos de agua, tanto en Guatemala como en El Salvador, con superficies que variaban entre unos pocos metros cuadrados y varias hectáreas. Algunos de ellos fueron construídos técnicamente en propiedades particulares pero con fines deportivos; pero la mayoría fueron cavados más o menos caprichosamente y fueron aprovechados de una manera ocasional. Que se sepa, no existe una sola granja piscícola de tipo comercial que produzca pescado para el mercado. La única entidad de este tipo que se ha conocido fué en San Antonio Jutes, a 65 km. al sur de la Ciudad de Guatemala, que suspendió sus actividades al venderse la finca, que hoy se dedica al cultivo de café.

Cuadro III

Producción calculada por hectárea y por año en Guatemala de varias especies cultivadas en estanques
(Se tomaron en cuenta solamente los ejemplares de tamaño comercial de 14 o más cm)

Especies		Kilos por hectárea por año	
		Mínimo	Máximo
Istatagua	Cichlasoma motagüense	45	239
Juilín	Thamdia guatemalensis	24	159
Sábalo	Brycon guatemalensis	3	17
Mojarra azul	Cichlasoma guttulatum	-	107
Mojarra negra	Cichlasoma macracanthus	-	17
Guapote tigre	Cichlasoma managüense	0	186
Carpa de espejo	Cyprinus carpio	296	2,170

Todos los peces recibieron alimentación artificial

El éxito transitorio de esta granja demuestra que es factible, en óptimas condiciones, cultivar carpa con beneficios satisfactorios. Alcanzó a tener un rendimiento de 3,750 kg. por hectárea y por año, gracias a su ubicación y condiciones de clima favorables, a la abundancia de agua apropiada, y especialmente a una alimentación barata a base de sobrantes de una industria de fécula de maíz. Pero los factores más importantes eran la habilidad del propietario y su voluntad de trabajar inteligentemente, y la existencia de un mercado pequeño pero constante, que consistía de emigrados europeos acostumbrados a comer carpa, y dispuestos a pagar un precio razonable.

Esto nos lleva a la conclusión que, aunque en condiciones favorables la piscicultura es una actividad lucrativa, el costo en construcciones, mano de obra, y alimentación de los peces implica la necesidad de tener compradores con dinero en la mano - la producción no es gratuita- y que el granjero que decide dedicarse a la piscicultura comercial con fines lucrativos esté dispuesto a trabajar y a adquirir ciertos conocimientos técnicos, como es el caso para cualquier cría o cosecha. Es posible que la lentitud con que la piscicultura se ha desarrollado en la América Latina se debe en parte a una mala interpretación en este sentido.

El Sr. Mario A. Saavedra, Técnico Pesquero de la Dirección General de Recursos Naturales Renovables en Guatemala, después de trabajar largos años en colaboración con el experto de la FAO - Sr. S.Y. Lin - recibió una beca de esta Organización para estudiar en la Universidad de Auburn, EE.UU. Recién reincorporado a su actividades en Guatemala, el Sr. Saavedra demostró gran entusiasmo para la implantación de los sistemas aprendidos.

Según los más recientes informes, el gobierno invertirá entre 1966 y 1970 una suma superior a un millón de dólares en un proyecto de riego del que el Departamento de Recursos Hidraúlicos se encargará de la construcción de estanques piscícolas y pequeños embalses, mientras que el Departamento de Piscicultura producirá jaramugos y fomentará la siembra, fertilización, alimentación y cosecha del pescado para el mercado.

Las crías para las estaciones modelos que se construirán serán preparadas en las estaciones de Bárcenas y San Jerónimo, que además entregarán jaramugos a personas que deseen comercializar el pescado bajo el asesoramiento técnico del Departamento.

Actualmente se dirige la construcción de un centro productor de pescado ya con carácter comercial en el Departamento de Zacapa, el cual tiene tres estanques ya en la fase final de construcción con un embalse total de 15,000 metros cuadrados.

Los funcionarios responsables tienen el propósito de demostrar que la piscicultura es un negocio rentable en Guatemala, y esperan interesar a numerosos inversionistas para intensificar estas actividades.

Entre 1959 y 1962 estuvieron dos expertos de la FAO en Nicaragua, encargados de asesorar al Gobierno en materia de pesca (Sr. S.Y. Lin (China) y Dr. D.R. Riedel (República Federal de Alemania)). En la actualidad (1965) el Dr. J.M. Cordini (Argentina) desempeña las mismas funciones.

El trabajo de estos expertos se ha concentrado en la eventual explotación de los grandes lagos y de los mares, habiéndose creido que la piscicultura era de importancia secundaria. Se sabe que el Ministerio de Economia ha construido recientemente cerca del Lago de Managua, una serie de estanques para el cultivo de carpas, en los que se ha logrado una alta tasa de crecimiento.

Según información recibida de la Sección de Pesca y Vida Silvestre del Ministerio de Agricultura de Costa Rica, se ha observado que algunas personas mantienen Guapotes (Cichlasoma sp.) en estanques situados a diferentes alturas sobre el nivel del mar, sin que exista una piscicultura organizada, "ya que el interés que les guía es únicamente el placer de tenerlos en sus fincas y no el de hacer de ellos una explotación comercial". Los ensayos del Gobierno se han limitado a la observación del crecimiento de C. dovii - el Lagunero de Nicaragua - habiéndose comprobado que los ejemplares menores (hasta de 5 cm.) se adaptaron al cautiverio, pero con una tasa de crecimiento muy reducido: aproximadamente un centímetro cada semestre. Los ejemplares mayores no se adaptaron, saltaban del estanque y no aceptaban comida alguna.

En Panamá hasta ahora no existen proyectos de piscicultura, debido al hecho de que ningún centro dista mucho del mar. Se ha introducido la trucha arco-iris (Salmo gairdneri) con algún éxito en tierras altas, y el Tucunaré del Brasil en algunos lagos y embalses a niveles más bajos.

4 AMERICA DEL SUR

Aunque el cultivo de algunos salmónidos y del pejerrey (familia Atherinidae) ha tenido éxito en Argentina y Chile (principalmente con fines deportivos), estas actividades, que son de aguas frías, quedan fuera del alcance de este informe.

En Brasil, las actividades del Departamento Nacional de Obras contra las Sequías en el Nordeste del país son bien conocidas; consisten principalmente en la producción de jaramugos de varias especies de peces nativos (principalmente Prochilodus spp. - fam. Characidae) para su introducción en los embalses, sin que hasta la fecha exista piscicultura en estanques para fines comerciales. En el resto del país, se había registrado en 1964 un número de piscicultores que oscilaba alrededor de 1,700, sin que sea posible saber cuál haya sido su producción, ni cuantos de ellos están, en realidad, trabajando activamente. Las únicas actividades en este campo que existen en escala comercial son las de cría de carpas en Sao Paulo y Paraná, para servir a un mercado muy limitado entre las colonias italianas y japonesas, sin que haya sido posible conseguir datos en cuanto a la producción se refiere. Hubo un intento de criar Tilapia en Sao Paulo, que solo tuvo éxito al principio, habiéndose producido una disminución progresivo de tamaño por exceso de población en los estanques debido a la falta de procedimientos técnicos. En la estación experimental de Pirassununga (estado de Sao Paulo) se ha empezado la cría de Tilapia por el sistema de monosexo, sin que todavía exista una producción comercial. En la Universidad Rural (Km. 47 de la carretera Rio/Sao Paulo) ya existe una producción de alevines de Tilapia para la venta al público, que se espera tenga resultados positivos en el futuro. No se sabe todavía si se han tomado las medidas necesarias para evitar la mencionada reducción de tamaño proveniente de la producción incontrolada.

El Jefe de la Sección de Pesca Interior y de Piscicultura de la Superintendencia Federal de Pesca en Rio de Janeiro informa que en la actualidad se estudia la producción de Tilapia, que desova practicamente todo el año, en combinación con predadores (Black Bass y Tucunaré) a razón de un predador por tres Tilapias. Fué constatado que los estanques de dimensiones de 20 x 50 metros son los más económicos para la explotación comercial. En aguas de 26°C se pueden sacar 900 kg. por tanque y por año con peces de 250 gr. cada uno, o sea a razón de 9000 kg. por hectárea. Tambien existe, tradicionalmente, la cultivación natural de Tainha (Mugil sp.) en aguas salobres de Recife. Se espera que estas actividades podrían dar lugar, en un futuro no muy lejano, a una producción efectiva de peces en estanques para fines alimentarios.

En Colombia se creó un Instituto de Piscicultura en Buga, cerca de Cali, en el Departamento del Valle. El edificio es bueno, pero carece de la superficie de agua necesaria para estos casos. Se han sembrado Tucunarés (Cichla ocellaris) traidos de los llanos orientales, en algunas fincas particulares, pero principalmente para deporte. Fué en esta Estación que se llevó a cabo el Centro de Capacitación de Piscicultura organizado por la FAO en 1962, y el encargado visitó México en viaje de estudios de la FAO, de donde había traído ejemplares seleccionados de la Carpa Espejo de Israel, que no se ha propagado debido a la promulgación poco después de un Decreto declarando la ilegalidad de la carpa en Colombia.

Los informes sobre la cría de jaramugos de carpa en la Laguna del Sauce en Uruguay indican un aumento desde 2 millones de jaramugos en 1960, hasta 6 millones en 1964. También hubo pequeñas cantidades de black bass, gobios, mojarras Cichlasoma y Lepomis. No existe información disponible sobre la producción total estimada.

Cuadro IV

Datos suministrados por el Gobierno del Uruguay
(Estación de Piscicultura de la Laguna del Sauce en etapa experimental)

	1960	1961	1962	1963	1964
Miles de jaramugos distribuidos (E)					
Carpas	2.000	3.000	4.000	5.000	6.000
Black Bass	5	5	10	10	10
Atherínidos mexicanos(?) (Pescado blanco)	-	-	-	-	20(Pejerrey?)
Miles de jaramugos capturados en aguas abiertas (en miles)					
Carpas	-	2	3	5	-
Mojarras (Cichlasoma y Lepomis)	30	30	1	10	-
Black Bass	15	20	40	60	110
Atherínidos mexicanos (charal)	-	-	5	-	-(Pejerrey?)
Gobios (Dormitator sp.)	-	-	5.000	-	-
Producción total en toneladas	No hay datos				

5 ZONA DEL CARIBE

Las autoridades de Puerto Rico informan sobre la existencia en 1964 de 290 granjas con 350 estanques de piscicultura, con una superficie total de 135 hectáreas, dedicados a la producción de Tilapias, Lubina, y dos especies de Lepomis, con una producción total anual estimada en 25 toneladas, o sea un promedio de 185 kg. por hectárea por año. La producción de jaramugos para su distribución fué de 6,200 Tilapia mossambica; 8,600 Lepomis ("red breast Sunfish" y "shellcracker") y 2,100 Lubina (Micropterus salmoides).

En 1952/53 el experto Sr. S.Y. Lin estuvo en Haiti y la República Dominicana. En vista de que ninguna de las especies de las aguas dulces en la isla tuviera una tasa de crecimiento y de reproducción suficiente para soportar una pesquería de importancia, mucho menos una piscicultura en escala comercial, fueron introducidos la Carpa y la Tilapia. Estas fueron criadas en sendas estaciones de piscicultura, con resultados satisfactorios no solamente en cuanto a la producción se refiere sino también en lo que concierne la aceptación. El autor de este informe ignora la situación actual a este respecto.

6 DISCUSION

Los incipientes programas de piscicultura en la región consisten, en algunos casos, simplemente en la introducción de peces de aguas naturales, la cual no está muy bien controlada. En otros casos se suministran jaramugos, también sin el control ni el estudio de los resultados obtenidos, a las personas que los solicitan sin que éstas tengan los conocimientos necesarios para su utilización. Como consecuencia de esto es necesario reconocer que los resultados de estas actividades, no son comparables con el esfuerzo económico proporcionado por los gobiernos.

La información suministrada por los gobiernos demuestra que solamente una minoría de ellos han obtenido resultados positivos de sus programas de piscicultura y que después de varios años de ensayos a diferentes niveles, en general no existe en ningún país una industria organizada sobre bases técnicas.

Conviene examinar cuidadosamente cuales son los obstáculos que han impedido el progreso en este sentido, y por qué no ha sido posible implantar "métodos cuidadosos e intensivos que permitan aumentar la producción natural de organismos seleccionados, en las épocas más propicias para su óptimo aprovechamiento"[1].

Algunas de las personas con experiencia en los programas mencionados dieron su opinión en cuanto a las posibles causas de la situación anómala por la que la inversión de sumas considerables en estaciones gubernamentales no han producido los resultados esperados. Se exponen a continuación las causas más frecuentemente avanzadas:

(1) Falta de personal técnico en todos los niveles - en las instituciones oficiales, especialmente en lo que se refiere a los servicios de extensión, y entre los granjeros.

(2) Desconocimiento de las posibilidades, de parte de los inversionistas.

(3) Poca aceptación de parte de la población para ciertas especies y falta de experiencia con otras especies más prometedoras (por ejemplo, lisas, bagres, etc.)

(4) Algunos informantes opinan que la piscicultura solamente producirá beneficios cuando sea emprendida en escala comercial, con personal profesionalmente preparado, y próxima a un mercado remunerativo. Estas personas se muestran pesimistas en cuanto a la viabilidad y practicabilidad de las pequeñas operaciones, que no solamente producen un impacto insignificante en el cuadro alimentario, sino que representan costos desproporcionados para el gobierno. Algunos expresan la opinión que los proyectos basados en la producción de pescado muy barato son llamados a fracasar.

(5) Cuando los ensayos recomendados por el gobierno no han dado los resultados anunciados, el campesino pierde interés. En algunos casos ha sido informado que es posible producir grandes cantidades de pescado en una superficie reducida, sin costo y con poco trabajo. Cuando encuentran que no es así, pierden interés.

1/ K.F. Lagler, Informe final del Contrato entre las Universidades Kasetsart (Tailandia) y Hawaii, 1965

(6) Aparte de los conocimientos técnicos, existen consideraciones de orden económico, social y aún político. Es necesario averiguar si estos obstáculos son reales o aparentes.

Los resultados de esta encuesta no coinciden necesariamente con las convicciones de este escritor, pero cada una de las ideas expuestas merece ser considerada objetivamente. Lo cierto es que, en teoría, existen áreas en la región donde las condiciones parecen ser favorables a la piscicultura, siempre que se establezcan las normas aplicables a cada caso. Si es verdad que la piscicultura solamente produce resultados en escala comercial, también es cierto que nunca se ha promovido esta clase de actividad.

Partiendo del principio que es necesario cambiar de táctica, convendría tal vez que algún gobierno de la América tropical patrocine un proyecto piloto en escala comercial con el fin de comprobar si es factible o no cultivar peces con fines de lucro, mediante la aplicación en la práctica de sistemas comprobados, y con bases estrictamente técnicas. Una vez publicadas las conclusiones, que deben incluir datos completos sobre inversiones, costos y beneficios, es de esperar que las personas que así lo deseen, con la ayuda inicial del gobierno, puedan adoptar estos mismos sistemas, que con el tiempo se diseminarían también en los demás países.

En la opinión de este escritor, y de otras personas informadas, sería éste el único camino posible para comprobar si la piscicultura puede establecerse como actividad útil, para así convertir en realidad los resultados hasta ahora logrados, que en su mayor parte han sido apenas teóricos. Es evidente que un experimento de esta clase debe sujetarse a un estricto control y contabilidad.

Si una demostración de esta naturaleza resulta muy onerosa para ser emprendida por un solo gobierno, se podría considerar la organización de un Proyecto, patrocinado por un grupo de paises, bajo uno u otro de los Programas Internacionales de Asistencia Técnica.

Se sugiere además que es indispensable un amplio intercambio de información entre las varias regiones mundiales, y eventualmente de técnicos y de especies cultivables. Por ejemplo, algunas especies que son tradicionalmente objeto de cultivo en Asia son completamente desconocidas en la América Latina. A la inversa, (aunque los resultados hasta ahora parecen ser negativos), todavía es posible que algunas de las especies neo-tropicales sean de utilidad en otras partes del mundo.

El primer paso hacia este intercambio de conocimientos sería la colección y estudio, por parte de los organismos gubernamentales competentes, de la voluminosa literatura existente, la cual es muchas veces desconocida y segundo la publicación a título de intercambio de los informes sobre los resultados obtenidos en la región.

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STATUS OF FISH CULTURE IN ASIA AND THE FAR EAST

by

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Abstract

Fish culture in Asia and the Far East is several thousand years old and the greatest developments have been in brackish-water culture for milkfish in Java and the Philippines and pond culture of various species of carps in China and India. The only significant recent introduction is of Tilapia mossambica, but methodology has been improved by the introduction of the technique of induced spawning in several of the more important carp species. Culture methods include the farming of brackish and freshwater ponds and the cultivation of fish in rice fields. The use of fertilizers and of supplementary feeds is not well developed except in certain cases where intensive culture is conducted. Until recently most of the stock used in fish culture came from wild-caught fry of the various species except for the common and golden carps which have been bred under culture conditions in most of the countries to which they have been introduced.

Governments throughout the region have encouraged fish culture as a source of badly needed animal protein. There is an important future for fish culture in the mainland areas of the region although this may be inhibited by the development of communications providing more readily available supplies of fish from marine sources. There exists throughout the region an immense potential for the development of brackish-water culture of fish and marine organisms.

SITUATION DE LA PISCICULTURE EN ASIE ET EN EXTREME-ORIENT

Résumé

En Asie et en Extrême-Orient la pisciculture qui est pratiquée depuis des millénaires a obtenu les résultats les plus remarquables dans l'élevage en eau saumâtre du Chanos à Java et aux Philippines et l'élevage en étang de diverses espèces de carpes en Chine et en Inde. La seule espèce importante d'introduction récente est le Tilapia mossambica, mais les méthodes ont été améliorées grâce à la technique de reproduction artificielle appliquée chez plusieurs des principales espèces de carpes. Les méthodes d'élevage comprennent l'exploitation des étangs d'eau saumâtre et d'eau douce et la pisciculture en rizière. L'utilisation d'engrais et d'aliments d'appoint n'est pas très répandue sauf dans certains cas où est pratiquée une pisciculture intensive. Jusqu'à une époque récente la plupart des sujets d'élevage provenaient de la capture d'alevins sauvages sauf dans le cas de la carpe commune et de la carpe dorée qui se reproduisent en captivité dans la plupart des pays où elles ont été introduites.

Dans toute la région, les gouvernements encouragent la pisciculture en tant que source de protéines animales dont la pénurie se fait cruellement sentir. Dans les zones situées à l'intérieur des terres, la pisciculture devrait connaître un grand essor à moins que celui-ci ne soit compromis par le développement de moyens de communication permettant d'assurer un ravitaillement plus facile en poisson de mer. Il y a, dans la région, d'énormes possibilités de développement de l'élevage des poissons et des organismes marins dans les eaux saumâtres.

SITUACION DE LA PISCICULTURA EN ASIA Y EL LEJANO ORIENTE

Extracto

La piscicultura en Asia y el Lejano Oriente cuenta con varios milenios de existencia, habiéndose producido los progresos más importantes en el cultivo del sabalote en aguas salobres en Java y las Filipinas, y en el cultivo en estanques de distintas especies de carpas en China y la India. La única introducción importante creciente es la Tilapia mossambica, pero la metodología se ha mejorado con la introducción de la técnica del desove provocado en varias de las especies de carpas más importantes. Los métodos de cría incluyen el cultivo en estanques de aguas dulces y salobres y el cultivo de peces en arrozales. El uso de fertilizantes y alimentación suplementaria no está bien desarrollado excepto en aquellos casos en que se realiza un cultivo intensivo. Hasta hace muy poco la mayoría de la población empleada en la piscicultura procedía de jaramugos capturados en estado silvestre, pertenecientes a distintas especies, excepto por lo que se refiere a las carpas doradas y comunes, criadas en condiciones de cultivo en la mayor parte de los países en que se introdujeron.

Los gobiernos de toda la región han fomentado la piscicultura como fuente de las proteínas de origen animal que se tanto se necesitan. La pisicicultura de las zonas continentales de la región cuenta con un futuro importante, aunque las perspectivas pueden verse limitadas por el hecho de que el desarrollo de las comunicaciones haga que se pueda contar con más suministros de pescado de fuentes marinas. En toda la región existe un inmenso potencial para el desarrollo del cultivo de peces y organismos marinos en aguas salobres.

1 INTRODUCTION

During the past two decades, interest in the cultivation of edible fish under more or less controlled conditions has received considerable stimulus in Asia and the Far East. National fisheries development policies, keeping in mind the vulnerability of existing wild stocks of fish, particularly those in the fresh water, have emphasized the need for the application of existing knowledge and technique and the initiation of research to resolve local problems.

A major contribution to this problem is the "Handbook on Fish Culture in the Indo-Pacific Region" (FAO Fisheries Biology Technical Paper 11, 14, 1962). Based on a comprehensive manuscript prepared by (the late) Dr. Sundar Lal Hora and Dr. T. V. R. Pillay, the Handbook presents basic information concerning fish culture in the Region and is a standard source book on the subject.

During the past three years, under the aegis of the Indo-Pacific Fisheries Council, further interest in the culture of suitable fish species has been developed and valuable papers on the subject have been published in the Proceedings of this Council. A further recent contribution is IPFC Occasional Paper 66 - A Preliminary Bibliography on Inland Fisheries, compiled by Mrs. A. Soulier.

2 THE REGION

The region, Asia and the Far East, incorporates some seventeen countries between Japan to the north, Australia to the South and West Pakistan to the West. The countries concerned are as follows:

Australia	Laos
Burma	Malaysia
Cambodia	Nepal
Ceylon	Pakistan
Hong Kong	Philippines
India	Singapore
Indonesia	Taiwan (Republic of China)
Japan	Thailand
Korea	Vietnam

3 DEVELOPMENT OF FISH CULTURE

Fish culture was probably initiated in mainland China and in India several thousand years ago and in Japan shortly thereafter; in this sense it may be regarded as indigenous to these countries but its development in virtually all the other countries came much later in the Christian Era. Probably the first major development was the establishment of the tambak system for brackish-water fish culture in Java, between 1200 and 1400 B.C. under the influence of the Hindu empire.

In the Philippines, brackish-water culture also developed several hundred years ago and the movement of Chinese traders and the establishment of trading posts was probably responsible for the introduction of carp culture into many of the countries of the region. Within the tropical zone, the abundance of natural supplies of fish rendered fish culture unnecessary and it is only within the last century and in some cases within the last 20 to 30 years that serious attention to the artificial cultivation of fish in controlled ponds has developed in such countries as Malaysia, Thailand, Vietnam and Pakistan. The collection of wild-spawned carp fry of the group of fishes known as the Indian major carps (Catla catla, Labeo rohita, L. calbasu and Cirrhina mrigala) is probably as ancient historically as the

Japanese development of the industry. Only within the past few years has there been interest in the development of pond culture in such countries as Cambodia, Vietnam, Burma, and Ceylon.

4 REVIEW OF THE HIGHLIGHTS IN FISH CULTURE

The most important stimulus to fish culture development in South East Asia during the past 20 years was the introduction of the exotic species Tilapia mossambica. The readiness with which this fish responded to artificial cultivation and the easiness with which it could be bred and fed, created a furore throughout the region.

Unhappily the extreme fecundity of the species and the fact that it breeds continuously throughout the year have created their own problems and over the past few years the interest in this species has declined. Only in rare cases has any serious attempt been made to apply adequate management techniques to the pond culture of Tilapia.

Considerable success in mono-sex-culture of this species was obtained in Sabah and experimental studies at the Tropical Fish Culture Research Institute, Malacca, have produced hybrids which seem to offer high potential for cultural activities. The crossing of Tilapia mossambica and a different species derived from South East Africa results in the production of 100 percent male offspring. These fish have considerable hybrid-vigour and, if segregated, show an excellent growth rate. This hybrid is not as yet widely cultivated.

Almost concurrent with the development of the Tilapia hybrid was the introduction into this region of the techniques of induced spawning by injection into the muscle or body cavity of extracts prepared from the pituitary gland of other fish. Initiated in the early 1920s in America this technique has been successfully utilized during the past decade in Taiwan, at Cuttack in Orissa State and other states of India, and in Japan.

In Taiwan, the technique has been used to induce spawning in the major Chinese carps, particularly the grass carp (Ctenopharyngodon idella), silver carp (Hypophthalmichthys molitrix), bighead (Aristichthys nobilis),and mud carp (Cirrhina molitorella), traditionally cultivated species of which for many years the only source of supply was Canton to which the fry collected from the Pearl River were brought and thence exported.

In India, the induced spawning technique has been utilized with very great success on the Indian major carps, mrigal (Cirrhina mrigala), rohu (Labeo rohita), catla (Catla catla), and calbasu (L. calbasu). Several generations of this fish have now been produced by this technique and there is no evidence of deterioration of the stocks. In India also hybrids between the major carps have been produced and the work in this direction is continuing. At Cuttack, the Chinese grass carp and silver carp have responded satisfactorily to induced spawning technique.

The development of a technique of transporting fry and fingerlings in closed containers with an atmosphere of pure oxygen has been a major step forward. These containers are made of either metal or, more frequently nowadays, of plastic bags. The number of fish transported per gallon of water has been increased manifold.

In Japan considerable attention has been paid to the production of Salmonoid hybrids showing hybrid vigour and increased growth rate; this work is continuing.

5 METHODS OF CULTURE

Methods of pond culture of fishes vary considerably throughout the region. The brackish-water fisheries for milk fish (Chanos chanos) in Indonesia, Philippines and Taiwan, are major commercial operations not infrequently with well established government research services closely linked to them.

The cultivation of the carps including the common carp, Chinese carps and Indian major carps is essentially a commercial operation although small family ponds are not uncommon.

The rice field culture of several species is proving successful in many areas most particularly in Indonesia where an elaborate system of breeding, rearing and growing for sale has been developed and is an intrinsic part of the otherwise almost wholly rice dominated farming practices.1/

Attempts in the culture of fish in rice fields in Thailand, the Philippines, Burma and Vietnam have not always been successful, largely due to lack of adequate governmental extension services to transmit the knowledge of the techniques and practices to the farmers themselves. Several species are used for cultivation in rice fields, most particularly the common carp (Cyprinus carpio), the tawes (Puntius javanicus), and in some areas the pla salid (Trichogaster pectoralis), this latter species more particularly in Malaysia and Thailand while the tawes is popular in Java and Malaysia.

Only rarely are organic fertilizers added to the ponds; one outstanding exception being Taiwan where the preparation of the milkfish ponds is a matter of very precise technique. The addition of animal manures and compost to fish ponds is fairly wide spread, but the quantity of fertilizers added tends to fluctuate markedly on the basis of availability.

6 FEEDS AND FEEDING

In the vast majority of cases, little is given in the way of supplementary food to the fish in the ponds. In brackish-water ponds, additional fertilizer ensures adequate growth of the algae upon which the milkfish and mullet feed. Only in the case of the culture of the Chinese carps is a routine feeding system well established.

In this instance the food given consists of soft vegetation and grasses which are cut from the area surrounding the pond or from other open land. In certain areas where common carp are cultured under intensive conditions, food such as soybean meal, rice bran and similar agricultural products may be given.

In almost all cases the food stuffs used are locally available at little or no cost and certainly in the tropical part of the region, the development of routine feeding systems has been inhibited by the necessity to keep the cost of production of the fish to a minimum in order to permit the cultivator's produce to compete in the market with the wild-caught supplies.

7 FERTILIZATION

Reference has been made above under "Methods of Culture" to this question. In almost all countries in the region the cost of inorganic fertilizer has been virtually prohibitive and only in such cases where the cultivated product is assured of a high market price, can inorganic fertilizers be used economically.

Moreover, in the tropical areas with a 12 months'growing season and a rapid nutrient turn over, there is little advantage to be gained under the current cost structure by the application of inorganic fertilizers.

As noted above, composting and additional animal manuring are undertaken fairly widely and these involve no cash cost to the pond culturists since the material used are normally waste products of the farm community.

8 STOCK

Throughout the region and with the outstanding exceptions of common carp, golden carp and tilapia, the greatest proportion of cultivated fishes are obtained from natural waters. These include, the eels (Anguilla japonica) in Japan and Taiwan, which are collected as elvers ascending the stream, the milkfish all of which are taken as early fry along the sandy

1/ Proc.Indo-Pacif.Fish.Coun., 7(3): Symposium on Fish Culture in Rice Fields (1958).

beaches joining river mouths, the major Chinese carps, major Indian carps, grey mullets and catfish of the genus Pangasius.

Following and latterly in part causing the diminution in export of major Chinese carp from Canton via Hong Kong, intensive efforts to induce the spawning of these species by pituitary injection have resulted in large commercial quantities of these fish being produced particularly in Japan and Taiwan and to a less extent in India. In India, the supply of Indian major carps taken from natural spawning grounds is still of very great importance, but over the past five years the development, initially at Cuttack and later in other government stations, of the successful application of pituitary injection technique has produced quantities of fish approaching the natural supply and there has been a marked stimulus in pond culture in these species.

The common carp and golden carp (Carassius carassius), are introductions into the warmer parts of the region and production of fry is wholly a culture operation. In many cases, the cultivators produce their own fry and raise them to commercial sizes. In some countries government hatcheries provide initial stock for cultural operations and these may be given free but more frequently the cultivators purchase the fry or fingerlings from the hatcheries. In Indonesia, a highly complex system of breeding and rearing has been developed and extends through the vast area of the rice cultivated lands particularly in Java.

There is a small import and export trade in milkfish fry but this has never developed to significant proportions, essentially because most of the countries from where the fry can be obtained do not have supplies adequate even for their own requirements.

As indicated above, the import/export trade in the major Chinese carps has declined steadily over some years and what was once the original and sole source of supply of this species is becoming less and less important in the industry. It is probable that in all the countries in which fish culture is developing, supplies of young stock are still inadequate to meet the demand.

To-date efforts to develop improved and selected strains of fish have had no significant impact on the industry. Nevertheless this aspect of fish husbandry has not been overlooked, but its development has, to some extent, been retarded by the fact that the hatchery operations are as yet not sufficiently large to meet local demands and there is a marked shortage within the region of scientists adequately trained for this highly specialized operation.

9 GOVERNMENTAL ACTIVITIES AND CONTROLS

In all the countries of the region, except Australia, the governmental approach to fish culture is strongly positive and within the limits of the available facilities, funds and personnel, greater or less extensive programs have been initiated. Except in the more highly developed countries in the region, research institutions are lacking, but all countries have a system of experiment stations and government fish farms designed to develop this phase of the fishing industry.

Connected with this activity, extension services are being developed but only in a few instances, have these achieved the degree of efficiency necessary for the active development of fish culture.

In this comparatively early phase of development of fish husbandry, excepting of course the culture of milkfish which has grown along ancient and traditional line, government control of operations is negligible and the legal aspects of government participation are still in most cases somewhat nebulous where they exist at all. The industry is essentially in embryonic form and much more experience and development will be necessary before precise legislation and official government control can be imposed.

The operation of cooperatives in this aspect of the industry has not been successful. In the majority of cases, the cooperative system has been imposed from above, has been sold to the people on the basis of subsidies and concession and has not arisen, as it should, directly from the felt needs of the operatives.

10 PROBLEMS AND PROSPECTS

There appears little doubt that there is an important future for fish culture in the mainland areas of the region. The development of the industry will depend to no small extent on the development of roads and communications and upon the extent to which the marine fisheries could expand. Modern marine fishing techniques, capable of producing fish at prices highly competitive with culture operations, will and at least in certain areas already are tending to discourage fish culture in inland waters.

The future for inland fish culture probably rests essentially in one of two developments; in the first place there is scope for further expansion at the subsistence level where the peasants can construct and operate fish ponds on agriculturally marginal land, not necessarily for profit but to provide in part the protein essential in the diet of himself and his family. It is unlikely that such operations will produce a cash crop but nevertheless they can have a strong impact on the nutrition of the people.

The other probable line of activity in inland waters will be the development of commercial operations in fairly extensive bodies of water and with intensive cultural practices employed.

There exists throughout the region an immense potential for the development of brackish-water culture of fish and other aquatic products and except in the case of milkfish there has been virtually no attempt to cultivate many of the endemic fishes, molluscs and crustaceans in coastal waters. The development of cockle culture in Malaysia is an interesting exception.

Perhaps the most important factor retarding the development of aquiculture has been the mental approach of the people themselves. Only comparatively recently has it been shown that there are major deficiencies in the protein supplies in almost all the countries in the region. The approach of the individual to this problem has not as yet changed in conformity with the changing conditions induced by the rapid growth of population.

Traditionally there has been enough food to harvest in the waters both inland and coastal and the concept of cultivation of these traditionally available items is entering into the thinking of the indigenous people, but slowly.

In assessing the problems and prospects of fish husbandry, the approach must at present be essentially a qualitative one. In virtually all the countries of the region, statistical services which would permit an accurate quantitative survey of the situation do not exist and such figures as are from time to time compiled, do, in the opinion of the writer, little more than create false impressions. Rarely are the compilations related to facts. It is possible that some may be reasonable estimates but it is probably extremely rare that the figures compiled can be substantiated by subsequent checks.

From time to time, articles and papers have been published, giving data relating to specific instances, places and times but it would be dangerous in the extreme to extrapolate from these to cover larger cases, times and areas.

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11 IMPORTANT SPECIES CULTIVATED

Species	Countries
Anguilla japonica	Japan, Taiwan
Chanos chanos	Burma, Ceylon, India, Indonesia, Malaysia, Philippines, Thailand, Vietnam
Tilapia melanopleura	Malaysia, Thailand
T. mossambica	Throughout the region (except Cambodia)
Aristichthys noblis	Hong Kong, India, Japan, Malaysia, Singapore, Thailand
Carassius auratus	Indonesia, Japan, Hong Kong, Malaysia, Thailand, Vietnam
C. carassius	India, Indonesia, Taiwan, Japan
Catla catla	Burma, India, Malaysia
Cirrhina mrigala	Burma, India, Malaysia, Pakistan
Cirrhina molitorella	Japan, Hong Kong, Taiwan
C. cirrhosa	India
Ctenopharyngodon idella	Burma, Hong Kong, India, Japan, Malaysia, Philippines, Singapore, Thailand, Vietnam
Cyprinus carpio	Throughout the region.
Hypophthalmichthys molitrix	Burma, Hong Kong, India, Japan, Malaysia, Philippines, Singapore, Thailand
Labeo rohita	Burma, India, Malaysia, Pakistan
L. calbasu	Burma, India, Pakistan
Osteochilus hasseltii	Indonesia, Malaysia, Thailand
Puntius gonionotus (javanicus)	Indonesia, Malaysia, Singapore, Thailand
P. schwanenfeldii	Indonesia, Malaysia
Oxyeleotris marmoratus	Malaysia, Vietnam
Helostoma temmincki	Ceylon, Indonesia, Malaysia, Thailand
Osphronemus gouramy	Ceylon, Indonesia, India, Malaysia, Philippines, Singapore, Thailand, Vietnam
Trichogaster pectoralis	Burma, Indonesia, Malaysia, Thailand
Mugil cephalus	India, Japan, Hong Kong, Taiwan
M. tade	India, Pakistan
M. corsula	India
M. dussumieri	India, Indonesia, Pakistan
Pangasius larnaudii	Thailand, Vietnam
P. macronemus	Vietnam
P. pangasius	Thailand
P. sanitwongsi	Vietnam
P. sutchi	Thailand, Vietnam
Etroplus suratensis	India, Ceylon

Various other species are from time to time reared in ponds, none however in any significant quantities and in many cases, particularly when wild-caught fry are stocked in ponds, undesirable species, e.g. predators, may be found.

12 CONCLUSIONS

The conclusions which may be derived from an attempted review of fish culture in the countries of South East Asia are simple. First, there is ample scope for development of culture practices in both fresh and brackish waters, both at the intensive cultivation level and in the efficient management of waters impounded primarily for other purposes. Secondly, there is great scope for development of governmental activity in the field, provided such activity is closely integrated with other policies and programs for protein production. Thirdly, there is an urgent need throughout the region for skilled personnel at all levels but particularly in the development of efficient and active extension services. Fourthly, basic research is necessary in certain areas of this subject, particularly in standardizing breeding techniques and in the evolution and establishment of improved species hybrids or strains of fish suitable for cultivation. New techniques of culture of both vertebrate and invertebrate fauna of the brackish and coastal waters need to be developed, but probably the most important outstanding requirement is the active application in almost all cases of existing knowledge.

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STATUS OF FISH CULTURE IN THE NEAR EAST REGION

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STATUS OF FISH CULTURE IN THE NEAR EAST REGION

Abstract

The Near East Region comprises Afghanistan, Bahrein, Federation of South Arabia, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Oman, Pakistan (West), Qatar, Saudi Arabia, Somalia, Sudan, Syria, United Arab Republic and Yemen. The limitations of the inland water regime in this region, which is predominantly arid, delimit its aquicultural development. However, the basins of the major river systems of the Nile, the Euphrates-Tigris and the Indus, and of several small rivers and streams as also a number of lakes, dams, reservoirs, springs, marshes, irrigation canals, and even scattered oasis pools and wet rice fields offer considerable possibilities for augmenting the natural fish crop through transplantation, management and other piscicultural operations. Moreover, recent stimuli provided through the establishment of experiment-cum-demonstration fish farms as in West Pakistan, Sudan, Syria, Iraq and the U.A.R., have resulted in a general awakening in fish culture, which can, in course of time, transform the cultivable waters into productive units to supplement the local protein supply for the growing population.

Statistics of pisciculture in the region are meagre; nevertheless, available data indicate that with progressive attention of the governments and the people and with the increase in skilled man-power in these countries, fish culture will come to play a role of appreciable importance in the Near East.

SITUATION DE LA PISCICULTURE AU MOYEN-ORIENT

Résumé

La région du Proche-Orient comprend l'Afghanistan, Bahrein, la Fédération d'Arabie du Sud, l'Iran, l'Irak, la Jordanie, Koweit, le Liban, la Libye, Oman, le Pakistan (occidental), Qatar, l'Arabie Saoudite, la Somalie, le Soudan, la Syrie, la République Arabe Unie et le Yémen. Dans cette région, qui est à prédominance aride, le développement de l'aquiculture est limité par le régime des eaux intérieures. Toutefois, les bassins des principaux systèmes fluviaux - Nil, Tigre-Euphrate et Indus - et de plusieurs petites rivières et cours d'eau ainsi qu'un certain nombre de lacs, retenues de barrages, réservoirs, sources, marécages, canaux d'irrigation et même de nappes d'eau dans certaines oasis et de rizières inondées offrent des possibilités considérables pour augmenter la production naturelle de poisson grâce à la transplantation, l'aménagement et autres opérations piscicoles. En outre, les résultats encourageants obtenus dans les élevages expérimentaux et de démonstration créés récemment au Pakistan occidental, au Soudan, en Syrie, en Irak et dans la R.A.U. ont suscité un intérêt général pour la pisciculture qui pourrait entraîner, par la suite, une transformation des plans d'eaux qui s'y prêtent en unités productives fournissant un supplément de protéines à la population toujours plus nombreuse.

Il y a peu de statistiques sur la pisciculture dans la région; néanmoins, les données dont on dispose indiquent qu'avec l'intérêt croissant que portent à cette activité les gouvernements et les populations et l'augmentation des disponibilités en main-d'oeuvre qualifiée, la pisciculture sera appelée à jouer un rôle appréciable dans les pays du Moyen-Orient.

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EL ESTADO DE LA PISCICULTURA EN EL CERCANO ORIENTE

Extracto

La región del Cercano Oriente comprende Afganistán, Bahrein, Federación de Arabia del Sur, Irán, Irak, Jordania, Kowait, Líbano, Libia, Omásn, Pakistán (occidental), Katar, Arabia Saudita, Somalia, Sudán, Siria, República Arabe Unida y Yemen. Las limitaciones del régimen de aguas continentales en esta región, que es predominantemente árida, delimitan su desarrollo acuícultural. Sin embargo, las cuencas de los principales sistemas fluviales del Nilo, del Eúfrates-Tigris y del Indo, y de varios pequeños ríos y arroyos, así como de algunos lagos, presas, depósitos, manantiales, pantanos, canales de riego e incluso grupos de oasis diseminados y campos de arroz inundados, ofrecen considerables posibilidades para aumentar los cultivos piscícolas naturales mediante el trasplante, la ordenación racional y otras operaciones piscícolas. Además, los recientes estímulos proporcionados mediante la creación de granjas piscícolas a la vez experimentales y de demostración en Pakistán occidental, Sudán, Siria, Irak y la R.A.U., han dado lugar a un despertar general de la piscicultura, que, con el tiempo, pueden transformar las aguas cultivables en unidades productoras para complementar el suministro local de proteínas necesarias a una población que crece sin cesar.

Las estadísticas sobre piscicultura en la región son escasas; no obstante, los datos existentes indican que con atención progresiva por parte de los gobiernos y el pueblo, con el aumento de mano de obra calificada en estos países, la piscicultura acabará desempeñando una función de apreciable importancia en el Cercano Oriente.

1 THE REGION

The Near East Region, bounded in general by the South East Mediterranean, the Red Sea and the Aden, Oman and Persian gulfs, covers the following countries:

Afghanistan	Oman
Bahrein	Pakistan (West)
Federation of South Arabia	Qatar
Iran	Saudi Arabia
Iraq	Somalia
Jordan	Sudan
Kuwait	Syria
Lebanon	United Arab Republic
Libya	Yemen

For official reasons, Israel, which is geographically within the region, is treated separately and hence the present note does not cover that country.

The region is predominantly arid and the limitations of inland water controls its aquicultural development. The eastern portion of the Sahara sweeps across the region through Libya and Egypt, and extends into Saudi Arabia and Kuwait. From there it is followed by the Sind desert of West Pakistan and the arid regions of Iran and Afghanistan. To the north, the semi-arid steppe becomes more and more Mediterranean in climate and vegetation, while to the south, the savannahs become sub-tropical in their rainfall and climate.

Three major river systems bring immense quantities of water into these arid zones from regions where rainfall is greater. The Nile flows north from a tropical zone; the Euphrates-Tigris flows south from the Turkish-Persian rainfall belt, and the Indus flows south-west from the Himalayas. Lesser rivers rise within the region, notably the Jordan, Litani and Orontes, which begin in the Lebanon and Anti-Lebanon ranges, fed by water precipitation from the Mediterranean. But the volume of water in these rivers diminishes greatly as they approach their mouths. Where they flow through brackish areas, their salinity rises. Many of the lesser rivers even fail to reach the sea, and finish by evaporating from lakes or from sebkhas or mud flats. Apart from the major river basins mentioned above, the region, in general, is characterized by deficient precipitation, high evaporation and the formation of basins with closed drainage and saline soils.

2 CULTIVABLE WATERS IN THE NEAR EAST REGION

While the fishery management of most of the following inland waters in the Near East countries would involve, either in part or in whole, some stocking and other piscicultural operations, the underlined items possess direct fish culture potential of varying degree.

Afghanistan

Some scattered farm ponds and reservoirs in the lower elevation around Kabul and at Sairobi and Wargak, the dams of Arghandab and Kajakai, the Helmand River and its tributaries such as the Tarnak, the Afghanistan and the Arghandab, some minor rivers like the Kabul, the Panshir and the Tagao Dare, a few mountain streams and springs, the Afghan stretches of the Oxus and the Amudarya and the irrigation channels in the agricultural sector.

Bahrein

A few spring pools as at Qassari and Adhari, some village ponds as in Sitra, garden tanks as at Bodaya and a number of mosque tanks distributed in the island.

Iran

The lakes of Bakhtegan, Nairiz and Razieh, the salt swamps or "kavirs", the dams and reservoirs like the Mangil dam, Shahmaz dam, and the Poleah Khaju, the rivers viz., the Karun, Kharkheh, Jerrahi, Mand, Djaje, Kand, Karaj, Gharasu, Zayandeh, Kur, Abu-Diz, Minab, Heraz, Talar, Gorgan and Habieh, the Caspian sea, the terminal stretch of the Euphrates-Tigris in the Shatt-el-Arab and the minor irrigation projects as at Shabankara, Ranan, Sar and Samman.

Iraq

The fish farms at Zafaraniyah and Latifiya, the farm ponds in the various Liwas, the reservoirs of dams and regulators, such as Derband I Khan, Dokan, Bekhme, Hindiya, Kut, Ramadi, Khan Bani Saad, Batmah, Wallal, Samarra, Meshkab, Yaoo, Hafar and Garmat Akaika, the large lakes of Habbania and Tartar, Abur Dibis, Hors Abu Nedjum and Bahr el Milh, the marshes like Howaiza, large irrigation canals like Dijaila and Garaf and the supply and drainage channels in date plantations and other agricultural areas.

Jordan

A number of seasonal and perennial catchments, a few reservoirs like the Solomon's pools near Bethlehem and the Roman reservoirs at Jerash, the fresh and brackish-water springs of which there are over a thousand in Jordan, and the pools associated with them such as the Azrak, the Ein Fashka, the Turabah, the Callirhoe and the Pela and the streams of Yarmouk, Zarka, Wadi el Wala, Wadi Mojib, Sueib, Arab, Ziglab, El Yarbis, Kufrinja and Hassa and the river Jordan.

Kuwait

A few brackish-water springs, canals and drains and the coastal backwaters in Keisan.

Lebanon

The springs of Anjar, Jessine, Terbol, Zahle, Ras el Ein, Leboueh Zarba and Hermel the brackish-water pools and backwaters on the coast, a few private garden tanks and reservoirs as at the Agricultural Nursery at Beirut, the perennial river Litany, the streams of Aouale, Nahr Beyrouth, Kalb, Nahr Ibrahim and Kadisha, the short perennial stretches of the Jordan and the Orontus and a few swamps like the Ameek swamp in the Bekka Valley.

Libya

A few scattered artesan waters as in the Fezzan, some spring pools like the Ain el Fras at Gadames and in oases like Wahat Yanbou (La Sorgente) and certain plantation channels as in Alba.

Pakistan (West)

Farm ponds and masonry tanks as in Lahore and Rawalpindi (about 52,000 ponds have been recorded in the former Punjab alone), lakes like Manchar, dams and reservoirs such as the barrages of Sukkur, Bakra, Ghulam Mohamed, Tounsa, Gaddu Kabri, Kaanhi, Malakand, Dargai, Warsak, Rasul, Kurra Gabri and Mianvab, irrigation canals like the Marala Ravi Link and the abandoned channels and pools under the Irrigation Department. The cold mountain waters of the Kaghan Valley, the Chitral and the Swat river hold very good trout culture potential.

Saudi Arabia

The oasis spring pools like Mansoor and Um Saba at Hofuf and other oases like Qatif, Sefwa and Tarut, Al Khadud, Fraihonna, Al Hagul, Mulhis, a few small lakes like Asfar, certain enclosed pools as in Jabrain and the irrigation canals in agricultural areas as in Wadi Gizan etc.

Somalia

The small river basins of the Schebeli and the Juba, a few pools, catchments of monsoon rains and the diversion canals, farm ponds, and irrigation tanks included in the National Development Plan.

Sudan

The Gordon's Tree Fish Farm, a few private fish farms near Khartoum, the rain-fed "Hafirs", which are reservoirs of drinking water with close autonomous drainage basins like the Gols reservoir in Darfur and the Mazdum and Dali reservoirs in the Upper Nile, and haffirs with at least temporary river connections as those in Malakal, several dam ponds, catchments and rain-fed tanks as in Ywatoga, Maridi, Nzara, Yambio and other parts of the Equatoria Province and the irrigation canals as in the Gezira.

Syria

The Government fish farm at Kalat el Moudik, the marshes in the Ghab Valley, the barrage reservoirs as at Rastane and Altkeya, the springs of Ain Taka, Cheria, Houach, Ain Cibine, Kalat el Moudik, Khadre, Fije and Ras el Ein, the lakes of Katuniyeh, Homs, Ran, Muzerib, the river valleys of the Nahr el Kabir, the Barada, the Senn, the el Awaj rivulet and the Syrian stretch of the Euphrates and its tributaries, As-Sajour Souyou, Balikh, Khabour, Djerdjib, Jarh-Jarh and Jerrah, the lagoon adjoining Lake Tiberias and the catchments as alongside the Safita Road near Tartouse.

The United Arab Republic

The Government fish farms at Serrow, Kanater el Khairiya Barrage, Manzalah, Nozha and Mex, private fish farms like the Hafez, the Oaes, the Kubeisa etc., the dam reservoirs specially the Nasser Lake and the Aswan Reservoir, the deltaic lakes of Mariut, Edku, Manzalah and Borullos, the backwaters of Port Fouad and Bardawil, the inland lake of Qarum, the coastal lagoons as at Mersa Matruh and Alamein, a few ponds and wet rice fields as around Serrow, the oases spring pools, channels and lakes as in Sewa, and the main River Nile and its extensive basin and canal systems for irrigation and navigation, besides the inundations under flood irrigation in the South. The Qatara depression and the Suez Canal connecting the Red Sea with the Mediterranean and the associated Bitter Lakes and the Ismalia Lakes may also be reckoned.

Yemen

The perennial streams and wadis fed by springs and floods such as the Mur, Rima, Sabid, Sadd and Sordud, the irrigation channels connected with the wadis, open wells and reservoirs fed by rain and ground water as around Sana and Yermin and parts of the Tihamas.

3 DEVELOPMENT OF FISH CULTURE IN THE NEAR EAST

Fish culture is unknown in many parts of the Near East, and among the nomads in the arid deserts, there are some who have never seen a fish in their lives. Apart from the limitations in the distribution of water bodies, the traditional role of meat and other animal husbandry products in the protein supply pattern of the Near East has also, in several areas, been in the way of fish being a popular article of diet. Nevertheless, along the coasts and river banks, fishing for the wild stocks has been going on for ages. Although a region-wide awakening is observed in fisheries exploitation, necessitated by increasing pressure on agricultural land and inadequate livestock production to cope with the fast expanding population, the practice of raising cultivated fish crop is a comparatively recent development even in the limited areas as in West Pakistan, Sudan, Syria, Iraq and the U.A.R. where some piscicultural activities have been started. It has, however, to be observed that as evident from the number and diversity of inland waters already listed in the previous paragraphs, there is considerable scope for the pisciculture utilization of a fairly wide range of cultivable waters in several countries of the region, including not only seasonal catchments, swamps and coastal lagoons, but also springs, oasis pools, farm ponds, reservoirs, dams, irrigation canals and lakes.

4 CURRENT PRACTICES AND ACTIVITIES IN FISH CULTURE

The current practices and activities in fish culture in the region may be summarized thus:

4.1 West Pakistan

In West Pakistan, starting from a few demonstration fish farms, fish culture is being extended and popularized, especially in the Lahore Division, where 70 fish farms were in operation in 1962 in addition to a dozen new ones in Rawalpindi.

Certain cultivable waters like the Manchar Lake, and the Marala Ravi Link navigation canal have been surveyed, and the natural fish stocks in them studied. The neglected channels and barren waters under the Irrigation Department are being taken up for pisciculture utilization. The third Five Year Plan (1965/66 to 1969/70) envisages such utilization of 30,780 ha of derelict water areas.

Attempts at artificial breeding are yet to meet with success. But fish eggs, fry and fingerlings are being collected from natural spawning grounds and nurseries and reared in specially constructed nurseries as near the Wassak Dam. These are stocked in an increasing number of cultivable waters such as tanks, canals, dams and reservoirs. A fleet of lorries for live fish transport has been provided.

Planting of desirable aquaflora like Vallisneria, Hydrilla, Potamogeton etc. in optimum densities is being attempted. The control of fish parasites like Argulus has been effected, e.g. at the Hiran Minar fish farm. An extension service in fish farming has been established.

Among the fish species cultivated are the indigenous carps, of which the rohu (Labeo rohita), the morakhe (Cirrhina mrigala) and the theila (Catla catla) are most popular. The common carp (Cyprinus carpio) has been introduced and is under observation. Tilapia, too, has been introduced; but the culture of Tilapia with carp in large masonry tanks like the Hiran Minar tank was reported to have affected carp production and angling prospects adversely, and Tilapia was therefore eradicated from the tank. Besides the warm-water species, trout is cultured in the Shinu hatchery in the Kaghan Valley and stocked in about a dozen stream stretches in the Valley. Operations have been extended to Chitral and also to the Swat river environs. Attempts at breeding other exotic species are also being made.

One of the two permanent fish culture training institutes in the Near East is the Kot Abdul Malik Training Centre near Lahore, established in 1958. Short and long range courses of training, ranging from eight days to six months for candidates at various levels are provided.

4.2 Sudan

In Sudan, the organization of fish culture has been based at the Experimental Fish Culture Station established in 1953 at Gordon's Tree. Although some hydrobiological studies have been attempted around this Station with the active collaboration of the University of Khartoum, the fishery research and production activities at the Station have been handicapped due to the limitations of personnel, program and equipment. Nevertheless, some practical fish culture has been extended to a number of localities in Sudan as in the Equatoria, the Kordofan and the Darfur Provinces. The fish production potential of the man-made canal systems as in the Gezira has been recognized, but remains to be developed. Stocking has been done in some dam ponds, catchments and rain-fed tanks in Ywatoga, Maridi, Nzara, Yambio and other parts of the Equatoria province.

The species cultivated are: Tilapia nilotica, T. galilaea and T. zillii; Alistes sp., Labeo nilotica, Labeo spp., Hydrocyon sp. etc.

A type of marine culture on the Red Sea coast has been established through a recent FAO/EPTA Project for shell fish. There are at present 120 private mother-of-pearl shell farms, and attempts at pearl culture have resulted in half-pearl blisters.

Regarding productivity, some studies have been made on diurnal changes of stratification and photosynthesis in some parts of the papyrus swamp in the "Sudd" and of the Gebel Aulia Reservoir.

Fish mortality studies have been taken on hand, and over-breeding and stunted growth in Tilapia are being tackled. Heterotis breeding has been planned.

4.3 United Arab Republic

In the United Arab Republic, fish cultural activities have been based at the Departmental fish farms at Serrow, the Barrage, Manzaleh, Nozha and Mex, while a few fish farms have also been established near the Barrage and Serrow. Rice-cum-fish culture is being attempted on a small scale in limited areas as around Serrow, where adequate water depth is available for an appreciable duration.

The main piscine problems which have been or are being tackled are: the age and growth rate of Tilapia, Lates and Mugil, the food of Tilapia, Barbus and Mugil and of certain predators, viz. Anguilla, Clarias and Bagrus, the breeding of Tilapia and Clarias

and the production rate of Cyprinus carpio, alone and mixed with Tilapia, Barbus, mullet etc. Hydrobiological and chemical surveys and primary productivity studies of cultivable waters like the Nozha Hydrodrome, parts of Lake Mariut etc. have been made.

Mullet transplantation started in 1920 in the Mariut Lake has been extended to other lakes including the inland brackish-water lake of Qarun. Fry of eel and sole have also been transplanted from Mex to the Qarun Lake where they have established themselves. The economics of such operations have been worked out recently. Among the exotic fish species which have been introduced into the U.A.R. are: Cyprinus carpio, Tilapia mossambica and the Chinese carp, Hypophthalmichthys molitrix. T. mossambica has been observed to be affected adversely by the low winter temperature while H. molitrix fingerlings have been thriving. T. macrochir and T. melanopleura are being tried for checking weeds and snails in the control of bilharzia. Indian major carps, viz., Labeo rohita, Catla catla and Cirrhina mrigala have also been proposed to be introduced.

Reliable figures of inland fish production from pond culture in the U.A.R. are not available, and the yield from the Nile River and from pond culture together reported to be 15 percent of the total catch is mostly from wild stocks.

4.4 Syria

In Syria, in the course of the past one decade of effort with the assistance of FAO experts, an experimental fish culture station has been established at Kalaat el Moudik, and a Fish Culture Training Centre organized in the premises. Besides raising fish crops for the market on a pilot project basis, fingerlings of different sizes required for stocking purposes are being produced at the farm. The inland waters have been surveyed and a commercial fish farm at Ain Taka has been designed. Large pieces of water like the Homs, the Ran and the Muzerib Lakes and the Rastane Barrage have been stocked.

Among the species dealt with at the station are: the common carp, C. carpio, introducted from Egypt, the Tiberias stock of carp, the indigenous tilapia, viz., T. zillii and T. galilaea and the local catfish, Clarias lazera.

The problems tackled at the farm include general pond management, breeding, hatching, nursery work, fertilization with superphosphate, artificial feeding with cotton seed cake and wheat bran, control of the fish parasite Argulus, and mixed-farming, including the raising of ducks in fish ponds.

4.5 Iran

Pisciculture in Iran had, in the past, been limited to a small effort at artificial breeding and stocking of sturgeon fry in the Caspian Sea. The FAO/EPTA expert assigned for an investigation on the inland fishery resources suggested, among other items, the introduction of the North American striped bass (Roccus sexatilis); but in view of the availability of other food fish species, the local authorities have not yet considered it desirable. In the opinion of the FAO expert the Karaj Lake, while not suitable for warm-water fish production, could be utilized for the sport fishery of trout. He found that a rich source of brine shrimp (Artemia) eggs for feeding sturgeon fry in hatcheries was available in the Razieh Lake, which otherwise would not be suitable for rearing fish on account of its high salinity and mineral contents.

Trout culture has been established at the Karaj trout farm and some stocking has been done in the Karaj and Sefi Rud dams and in the Sefi Rud and Djadje streams. In addition to continuing the stocking of suitable cold waters in Iran with trout, the farm authorities are keen to develop warm-water fish culture in the different cultivable waters in Iran.

4.6 Iraq

In Iraq, after a survey of the inland waters, including the cultivable ones, with the assistance of an FAO/TA expert, an experimental fish farm has been established at Zafaraniyah. The Japanese and Indonesian stocks of the common carp, C. carpio var. flavipinnis and five local species (Barbus xanthopterus, B. grypus, B. sharpeyi, B. luteus and Mugil hishni have been reared and studied.

Among exotic species which have been introduced into Iraq are: Tilapia nilotica and T. zillii from Egypt. Problems investigated at the experimental fish farm are: age and growth, food and feeding, predators and their control etc.

Carp fingerlings have been distributed to private fish pond owners especially at Latafiya, to garden pools and school tanks. Stocking has also been effected in larger pieces of water like the Habbaniya and the Wadi Thartar Lakes.

Spawning grounds in a few recognized sections of the Euphrates-Tigris System are being protected under fishery regulations, although the machinery to exercise the control appears to be inadequate.

The limitations of staff and funds have been in the way of speedy progress of the work over the widely distributed inland water bodies in Iraq.

4.7 Jordan

In Jordan, a few stray attempts in fish farming have been made as in the Azrak and Ain Fashka springs and in a private garden pond at Jericho. Moreover, the piscicultural possibilities of several other springs, pools, catchments, reservoirs and channels have been recognized, and a program for initiating the work is being started with the assignment of an FAO/TA expert.

4.8 Libya, Somalia and Arabian Peninsula

There is hardly any fish culture in Libya as also in Somalia and the entire Arabian Peninsula, although in some of the oases pools and irrigation and drain channels in Saudi Arabia as at Hofuf and Jabrain, larvicidal fish were introduced for malaria control and frog culture was attempted.

4.9 Kuwait

In Kuwait, no fish farming exists. The limited prospects for the culture of fish, shrimp and shell fish in the coastal backwaters, especially in Kheisan and of warm-water pond fishes in some of the brackish-water springs, canals and drains remain to be explored, though interest in this field has recently been expressed by some private individuals.

4.10 Lebanon

In Lebanon, an attempt to establish carp culture at a fish farm constructed at Terbol has not been successful on account of water shortage. A departmental trout culture centre has been established at the Anjar springs, and there are a few private hatcheries at Zahle and Jessine for rearing trout. Carp culture in reservoirs is undertaken by a few private parties around Beirut, while others have expressed some interest in brackish-water culture near the coast.

4.11 Afghanistan

In Afghanistan, the solitary case of fish culture is found in the Paghman hatchery of the Royal family where trout is reared, though some of the fish are reported to have been transplanted in a few reservoirs in the Kabul area.

In view of the popularity of fish as an adjunct to the sweet "jillaebi", there is scope for the development of fish culture on a modest scale by stocking selected pieces of available water bodies with species that can withstand the climatic extremes of Afghanistan.

4.12 Yemen

Although there is no fish culture at present in Yemen, with the return of the FAO-sponsored Yemeni Fellow, after his training at Kalaat el Moudik, it should be possible to initiate the survey of the cultivable waters, especially the reservoirs, irrigation channels, farm ponds and institutional tanks and to establish fish culture on a modest scale.

5 CONCLUSION

Statistical data concerning pisciculture in the Near East are, unfortunately, very meagre, and those available are being presented in an appendix to this report. However, from the foregoing pages it would be obvious that with progressive improvements in the amount of attention to fishery development bestowed by the Governments of the Near East, specially in land-locked areas, with the public's appreciation of the production potential of the valuable cultivable waters distributed in the different countries of the region and with the strengthening of the technical manpower in fisheries organizations, pisciculture will come to play a role of considerable importance in the Near East region.

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Appendix I

Statistics of progress in fish culture[1] in the Near East 1960 - 1964

Country	Year	PONDS: Fresh water: No of Unit	PONDS: Fresh water: No of ponds	PONDS: Fresh water: Area in ha	PONDS: Brackish water: No of Unit	PONDS: Brackish water: No of ponds	PONDS: Brackish water: Area in ha	RICE FIELDS: Fresh water: No of Unit	RICE FIELDS: Fresh water: Area in ha	RICE FIELDS: Brackish water: No of Unit	RICE FIELDS: Brackish water: Area in ha	Fish crop produced in m. tons	Stocking material in million: From hatcheries	Stocking material in million: From nature	REMARKS
U.A.R.	1960	3(a)	39	133	1	9	4	Figures not available				Figures not available		3.8(c)	(a) The three units are State owned experimental fish farms (b) Private farms. (c) Mullets only; for stocking enclosed lakes of Qarun and Edku and Nezha Hydrodrome
	1961	3	39	133	1	9	4	"						2.5 "	
	1962	3	39	133	1	9	4	"				"		2.9 "	
	1963	3(a) +(b)	114+9	400+36	1	9	4	"				"		5.4	
	1964	Figures not available												7.1	
IRAQ	1960	2	37	4				NIL				Figures not available		0.015(d)	(d) Carps
	1961	2	37	4				"						0.017	
	1962	3	39	4.5				"				"		0.018	
	1963	4	44	6				"				"		0.024	
	1964	6	80	26				"				"		0.026	
JORDAN	1960	Data not available						NIL				Figures not available	NIL		
	1961		"					"					"		
	1962		"					"				"	"		
	1963		"					"				"	"		
	1964	1	5	2				"				"	"		

[1] In the absence, in most of the Near East countries, of adequate agencies for statistics collection and compilation, neither completeness nor accuracy of the data is claimed.

I/RR-5

THE STATUS OF WARM-WATER POND FISH CULTURE IN EUROPE

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THE STATUS OF WARM-WATER POND FISH CULTURE IN EUROPE

Abstract

In the European region, fish culture in warm-water ponds goes back to the Middle Ages and, in France and Spain particularly, was closely tied to religious practices of the time. By scientific management and careful selection, it is now possible to obtain yields as high as 3,500 kg/ha for carp. The experimental culture of cold-water species such as trout, in water having a temperature of between 26,9°C and 29°C also give interesting results in Spain.

Although the purpose of fish culture in Europe is often restocking natural waters for sport and commercial fisheries, much intensive fish culture, oriented primarily towards food production is also carried out. Artificial feeding is widely practised. Gains obtained by feeding are hard to determine but in Israel, of 2,000 kg of fish obtained per hectare, probably 400 kg come from natural food, 400 kg more from fertilizers and 1,200 kg from artificial feeding. The food coefficient varies with the size of fish, so advanced methods require the sampling of the weight and rate of growth of the fish regularly. Stocking material usually comes from each country's own production, although new species are sometimes imported.

In most European countries, governmental assistance is given to fish culturists, either through the establishment of research institutes and experimental stations or in the form of direct financial assistance. In eastern Europe, the governments act as the central planning agencies for fish culture development.

The main problems facing warm-water fish culture in Europe are the inadequacy of water supplies, particularly in Poland and Israel; water pollution and fish diseases in western Europe. A list of species used for warm-water fish culture in Europe is given.

SITUATION DE LA PISCICULTURE EN ETANGS A TEMPERATURE ELEVEE EN EUROPE

Résumé

En Europe, l'élevage du poisson en étang à eau à température élevée remonte au Moyen Age. En France et en Espagne, notamment, il se rattachait étroitement aux pratiques religieuses de l'époque. Un aménagement scientifique et une sélection attentive permettent actuellement d'obtenir des rendements de l'ordre de 3 500 kg/ha pour la carpe. La pisciculture expérimentale, dans des eaux dont la température va de 26,9 à 29°C, d'espèces d'eau froide comme la truite donne également d'intéressants résultats en Espagne.

Si la pisciculture européenne vise fréquemment au repeuplement d'eaux naturelles à des fins sportives ou commerciales, il n'en existe pas moins une importante pisciculture intensive, orientée principalement vers la production alimentaire. L'alimentation artificielle est très répandue. Il est difficile d'évaluer exactement les gains obtenus par le nourrissage, mais par exemple en Israël, sur une production de 2 000 kg de poisson à l'hectare, on peut sans doute considérer que 400 kg viennent de l'alimentation naturelle, 400 kg de l'apport d'engrais et 1 200 kg de la nourriture d'appoint. Le quotient alimentaire variant avec la taille du poisson, les méthodes modernes exigent des sondages périodiques sur le poids et le taux de croissance. Bien que l'on importe parfois de nouvelles espèces, le matériel utilisé pour le repeuplement provient généralement du pays même.

Dans la plupart des pays d'Europe, les pisciculteurs reçoivent un appui des pouvoirs publics, soit par la création d'instituts de recherche et de stations expérimentales, soit sous la forme d'une assistance financière directe. En Europe orientale, l'Etat assure la planification centrale du développement de la pisciculture.

La pisciculture européenne en eaux à température élevée se heurte principalement aux difficultés suivantes: insuffisance de l'alimentation en eau, particulièrement en Pologne et en Israël, pollution des eaux (Europe occidentale), et maladies des poissons.

La communication renferme une liste des espèces utilisées en Europe en pisciculture en eaux à température élevée.

SITUACION DE LA PISCICULTURA EN ESTANQUES DE AGUA TEMPLADA EN EUROPA

Extracto

En la región europea, la piscicultura en estanques de agua templada se remonta a la Edad Media, y, especialmente en Francia y Españã, estaba estrechamente ligada a las prácticas religiosas de la época. Mediante la explotación en forma científica y la selección cuidadosa, actualmente es posible obtener rendimientos que llegan a ser de 3.500 kilógramos por hectárea para la carpa. El cultivo experimental de especies de agua fría tales como la trucha en aguas con temperaturas de 26,9°C y 29°C está dando también resultados interesantes en España.

Aunque la finalidad de la piscicultura en Europa es casi siempre la de repoblar las aguas naturales para las pesquerías deportivas y comerciales, también se llevan a cabo intensamente muchas actividades pisciculturales orientadas principalmente a la producción de alimento. La alimentación artificial se practica ampliamente. Es difícil determinar las ventajas obtenidas con la alimentación artificial aunque en Israel, de 2.000 kg de pescado obtenidos por hectárea, probablemente 400 kg proceden de la alimentación natural, 400 kg más de los fertilizantes y 1.200 kg de la alimentación artificial. El coeficiente de alimentación varía según el tamaño del pez, por lo que los métodos modernos requieren el muestreo en forma regular del peso y tasa de crecimiento de los peces. El material para la repoblación procede generalmente de la propia producción de cada país aunque a veces se importan especies nuevas.

En la mayoría de los países europeos se presta ayuda oficial a los piscicultores ya sea mediante la creación de institutos de investigación y centros experimentales, sea en forma de ayuda económica directa. En Europa oriental, los gobiernos actúan como organismos de planificación centralizada para el desarrollo de la piscicultura.

Los principales problemas con que tropieza la piscicultura en aguas templadas en Europa son la insuficiencia del suministro de agua, particularmente en Polonia e Israel, la contaminación de las aguas en Europa occidental y las enfermedades de los peces. Se da una lista de las especies utilizadas para la piscicultura en aguas templadas en Europa.

1 THE REGION

Geographically the European region is defined as the land and water areas lying between the Arctic ocean in the north, the Atlantic ocean in the west, the Mediterranean and adjacent seas and the Caucasian mountains in the south and the Caspian sea and Ural mountains in the east.

The following countries are in the European region:

Albania	Luxembourg
Austria	Malta
Belgium	Netherlands
Bulgaria *	Norway
Cyprus	Poland
Czechoslovakia *	Portugal
Denmark	Romania
Finland	Spain
France	Sweden
Germany, Federal Republic of	Switzerland
Greece	Turkey
Hungary *	Union of Soviet Socialist Republics *
Iceland	United Kingdom
Ireland	Yugoslavia
Israel	
Italy	

* not member of FAO

This paper is based on replies to a questionnaire sent to FAO member countries in the region practising warm-water pond fish culture. Replies were received from Belgium, Denmark, France, Federal Republic of Germany, Israel, Italy, the Netherlands, Poland, Romania, Spain and Yugoslavia.

2 DEVELOPMENT OF FISH CULTURE

European warm-water pond fish culture goes back to the Middle Ages. Fish ponds were often located near monasteries, such as the one at Grandjilla near San Lorenzo del Escorial in Spain, to provide "lean meat" during Lent which, at that time, was rigorously observed. The development of warm-water fish culture in Europe is often identified with carp culture. It is said that it was in the Middle Ages that carp was imported from the Orient via Cyprus, hence the name Cyprinus. Others claim that carp and its culture were introduced into Europe from China in the sixteenth century. According to certain authors carp is a component of the palaearctic fauna from the Danube system at least 1,500 years ago. Carp is also mentioned in the "Capitulare de Villis" of Charlemagne in 812 and by the German Kaiser, Rudolf II (1576-1612). Carp culture in Europe developed independently of that in the Far East with different culture methods.

In Romania, primitive fish culture has been practised since a very long time, but was limited to rivers and lakes. Documents concerning these activities go back to the twelfth century. Primitive fish culture in ponds developed parallel with the development of water mills. As soon as the water mills were motorized, the interest in pond fish culture decreased. In that country modern fish culture practices were introduced only after 1950.

In Italy and Greece, warm-water fish culture is practised in brackish-water lagoons where salinity can sometimes be regulated. In Italy, it takes place mostly along the coast off central and southern Italy and in Sardinia. Warm-water fish culture is also practised in Italy in rice fields in northern Italy during the warm summer months. Brackish-water fish culture is carried out in Israel.

Modern fish culture started in 1864 in Spain with the publication of the Manual practico de Piscicultura by Mariano de la Paz Graells who built in 1886 near Segovia an ichthyological laboratory for the culture of trout to stock streams and lakes. The Cuerpo de Ingenieros de Montes was made responsible for all work relating to fish breeding and restocking. In the same year, 1886, the private fish farm of the Monasterio de Piedra, near Zaragoza, was built for trout culture.

Pond fish culture is new in the Netherlands, Israel and Yugoslavia. In the Netherlands, it dates back to the nineteenth century. It expanded gradually and in 1963 the breeding areas were doubled by the construction of a new pond farm. At present, there are four fish breeding stations, with a total area of 320 ha used for warm-water fish culture. The fish raised in those farms are used exclusively for stocking rivers and lakes for sport and commercial fisheries.

In 1939, 15 ha of fish ponds were constructed in Israel. They yielded an average of 1,000 kg per ha. Since then, the extension of fish farming has been very rapid and today there are 4,800 ha under cultivation. In Israel, there are great limitations in pond building because of the shortage of fresh water and so brackish water is also utilized for fish culture.

Warm-water fish culture was introduced in Yugoslavia in the beginning of the twentieth century. Three varieties of the common carp (Cyprinus carpio) (scale carp - "schupner", big scale carp - "leder", and carp without scales - "spigler") were introduced in Yugoslavia from Poland and Czechoslovakia. There was no tradition of fish culture in the country before this. Fish culture is concentrated historically around the big rivers, the Danube, the Sava, the Drava and the Tisa, in the provinces of Slovenia and Vojvodina. The fish farms are very big. After the second world war, fish farming developed rapidly and now the area covered by fish farms is double that of the pre-war period, i.e. more than 10,000 ha.

3 LIST OF SPECIES USED FOR WARM-WATER POND FISH CULTURE IN EUROPE

Family / Species	Countries										
	Belgium	Denmark	France	Greece	Israel	Italy*	Netherlands	Poland	Romania	Spain	Yugoslavia
Acipenseridae											
Acipenser ruthenus									X		
Anguillidae											
Anguilla anguilla	X	X	X	X		X					
Atherinidae											
Odonthestes (Basilichthys) bonariensis						X[1]					
Centrarchidae											
Eupomotis gibbosus			X								
Micropterus dolomieui	X		X								
M. salmoides	X		X					X[2]		X	
Cichlidae											
Tilapia aurea					X						
Cyprinidae											
Aristichthys nobilis								X[3]	X		
Barbus sarana ?				X							
Carassius auratus			X			X		X[2]	X		
Carassius carassius						X		X[2]	X		
Ctenopharyngodon idella								X[3]	X		
Cyprinus carpio	X	X[4]	X	X	X	X	X	X[5]	X	X	X
C.c. specularis				X							
Gardonus rutilus	X		X					X[6]			
Hypophthalmichthys molitrix								X[3]	X		
Idus idus			X								
I.i.orpha								X[7]			
Mylopharyngodon piceus									X		
Scardinius erythrophythalmus	X		X								
Tinca tinca	X		X	X				X[8]	X	X	X
Abramis brama								X[6]			
Vimba vimba								X[6]			
Esocidae											
Esox lucius						X	X	X[2]		X	

Family / Species	Countries										
	Belgium	Denmark	France	Greece	Israel	Italy*	Netherlands	Poland	Romania	Spain	Yugoslavia
Mugilidae											
Mugil cephalus			X	X	X	X			X		
M. ramada						X					
M. capito				X		X					
M. chelo				X		X[9]					
M. saliens				X		X[9]					
Sparidae											
Chrysophrys aurata				X							
Percidae											
Lucioperca lucioperca			X				X	X[8]	X		X
Perca fluviatilis	X		X	X		X					
Ictaluridae											
Ictalurus nebulosus			X					X[2]			
Siluridae											
Silurus glanis											X
Serranidae											
Labrax labrax				X							
Salmonidae											
Salmo irideus										X[10]	
S. trutta										X[10]	

*In Italy only eels and Mugil are cultivated in brackish water, the other species are not cultivated but caught in warm-water ponds

1/ Imported in 1966 from Argentina
2/ Very few in numbers, no commercial value
3/ Imported from U.S.S.R. in 1964
4/ Small quantities for export
5/ Accounts for 97 percent of pond production
6/ For stocking natural waters only
7/ Fancy fish for parks
8/ For market and for stocking natural waters only
9/ Cultivated in brackish warm-water ponds
10/ Cultivated in warm-water ponds on a trial basis

4 REVIEW OF THE HIGHLIGHTS IN FISH CULTURE IN EUROPE

Belgium

There are no particular highlights worth mentioning in the progress of fish culture in Belgium. Progressively, the techniques were improved, as in the case of most European countries: scientifically controlled stocking, artificial feeding, use of fertilizers, artificial fertilization, introduction of new species such as the rainbow trout (Salmo gairdneri), and efficiency of transportation methods.

France

Two outstanding practices adopted in carp culture in France are (i) the general use of lime and phosphate fertilizers, and (ii) the use of royal carp (Cyprinus carpio var. royal). The following formula based on the hydrotimetric degree [1] of ponds has been worked out for the application of lime: $K = 20\ h\ (15 - D\ H)$; h being the depth of the pond at the sluice gate; D H the hydrotimetric degree and K the quantity of quick-lime required.

Since about 1920, a selected carp race derived from stocks originating in central Europe and called royal carp has been in use in France. It is characterized mostly by the length/weight ratio, which is no smaller than 2.6. The head is small in relation to the body and the back is curved.

Greece

In Greece, efforts are directed towards increasing production by use of artificial fertilizers and improved sites.

Israel

With the application of scientific knowledge and the careful adaptation of European fish culture methods to the particular climatic, water and soil conditions of Israel, it has been possible to raise the average yield from 1,000 kg/ha to 2,050 kg/ha with a maximum of 3,500 kg/ha in Israel. In many areas of Israel, water is scarce and often has a high saline content (up to 1,200 mg cl per litre). Such water is unsuitable for agriculture but well suited for fish culture. Where fresh water is available, ponds are made deep and water is stored during the rainy season to a depth which permits operation of the ponds with very little or no addition of water during summer. When the pond is emptied, the water is not always wasted; it is re-used by emptying the water into neighbouring ponds either by gravitation or portable pumps. With this or other suitable systems water can be used more than once.

Experiments conducted some years ago in different parts of Israel proved that natural fertility of ponds can produce 200-400 kg/ha. By adding fertilizers without supplementary food, production can be raised to 800-1,000 kg/ha.

The use of specialized equipment such as cylindrical net driers, concrete catching boxes, fish graders, efficient containers with a continuous supply of air for transport of live fish, food distributors and chemical sprayers have helped to reduce production costs.

Italy

In brackish-water ponds, eels (Anguilla sp.) are raised as well as certain species of mullets (Mugil spp.), gilthead (Chryosphrys sp.) and bass (Labrax sp.). In this extensive fish culture system no artificial feeds are used. Various devices are used to regulate the salinity of water and to capture fish.

In certain areas rice fields are stocked in the spring with small one-year-old carp (Cyprinus carpio) and cropped in the autumn for marketing.

1/ The measure of water hardness by the determination of calcium and magnesium salts concentrations.

Netherlands

In 1957, scientific management of the fish farms was initiated. Within a short time, a considerable increase in the production was obtained. At the fish breeding station in Valkenswaard, the yield quadrupled as a result of fertilization, feeding and selection (1957:200 kg/ha; 1964:800 kg/ha). Considerable importance is given to the time of stocking (temperature, food production in the ponds and condition of the stocking material). Selection of carp is specially emphasized. Among other things, cross-breeding with wild carp was carried out.

Poland

Rapid progress in carp breeding started in 1870 when T. Dublisch evolved the system of transferring carp from special spawning ponds to fry ponds, and then to fingerling ponds during the first season of rearing. This system was first applied in a fish farm near Cieszyn in southern Poland. Crop rotation, i.e. alternating between cereal and fish, was known in the seventeenth century. Fertilization, first applied in the 1930's has been widely practised since about 1950. Induced spawning of carp by hypophyzation has been practised since 1948.

Romania

The most important achievements in fish culture in Romania were made by the Fish Culture Research Institute. This Institute was founded in 1940 and transformed into the Research and Fish Culture Projects Institute in 1961. From 1950 to 1965 important work has been done on:

(i) fertilization to increase the trophic conditions of the ponds and thus carp production in ponds without plants or edible weeds;

(ii) combinations of species and the age classes for stocking and methods of fodder distribution for obtaining a gradual increase in average production of plant feeding fishes;

(iii) selecting carp and producing hybrids with better physiological and morphological characteristics. Artificial reproduction of carp has been developed in recent years and about 200 million fry are produced per year. New species of cyprinids have also been introduced.

Spain

In 1949, pike (Esox lucius L.) was introduced in Spain. The fish were raised in ponds and they successfully spawned at the age of one year.

To obtain a larger percentage of black bass (Micropterus salmoides) and to avoid cannibalism among the breeders, an artificial nest made of gravel and sand is placed over wooden planks or ceramic material with a cover. The embryos are then transported to the incubating tanks or ponds where the eggs hatch and the fry develop. In a similar manner, extensive culture of zooplankton (mainly Daphnia and Artemia) is carried out to feed the fry during its early stages. Those ponds are fertilized with superphosphate.

Experiments were also carried out in the culture of rainbow trout (Salmo gairdneri) and common trout (Salmo trutta) at high temperature (average monthly temperature of 26.9°C with a maximum of 29°C). 1/ The growth rates were as follows: from 5 to 23 g average weight at the age of five months, from 27 to 93 g at eight months and 110 g at 11 months.

The culture of trout in warm water is made possible by the oversaturation of oxygen of the water, with the use of aquatic plants covering 40 percent of the pond area, with abundant sunshine and shallow water.

Yugoslavia

In the last five years, important progress has been made in the culture of carp through improvements in the techniques of breeding, intensive feeding, increasing the density of stocks, artificial spawning, mechanizing the catching and transportation of fish and other techniques. As a result, production more than doubled from 500 kg/ha to 1,200 kg/ha in two years.

5 METHODS OF CULTURE

Belgium

Fish culture is carried out for the purpose of stocking natural waters and ponds. Carp, pike and eel are raised in warm-water ponds but only small quantities are intended for consumption.

There are very few installations exploited by the state and their production is used for stocking public waters. Fish culture is, generally, moderately intensive and artificial feeds and fertilizers are used.

France

Most of the fish cultured in France is consumed locally. However, in Dombes and Lorraine, production is centralized by cooperatives and most of it is exported to Germany. Fish culture is not practised in rice fields.

Carp culture in France is intensive only in about half the area of ponds where fertilizers are used with success. The practice of rotating crops (fish culture for two years and oat culture the following year) has given better results. In Dombes, this is called "évolage".

Greece

Government fish culture establishments in Greece are exploited by private enterprise or by cooperatives under Government grants. Private enterprises and fishermen's cooperatives also practise fish culture in rice fields under natural conditions; no artificial feeds are used.

1/ Studies and Reviews, General Fisheries Council for the Mediterranean No.30

Israel

In Israel, fish culture establishments are privately owned, although very often organized as cooperative enterprises. The Government has a fish breeding station at Dor, but the station does not engage in commercial operations. Fish culture is intensive and artificial feeding as well as fertilization are adopted.

Netherlands

Apart from cold-water fish culture, commercial fish culture enterprises are of very little importance. The breeding stations are managed on a semi-government basis. Cultivation is done intensively using fertilizers and supplementary feeding when possible.

Poland

According to 1964 data, the various fish culture establishments were divided as follows as far as ownership was concerned:

State	54,722 ha	
Cooperative	2,712 ha	
Private	5,206 ha	
Polish Angling Association	1,266 ha	(rearing ponds for stocking natural waters)

Ninety percent of the fish culture carried out is intensive, using feeds, fertilizers and weed control measures.

Romania

In Romania, the trend is to use land unsuitable for agriculture for fish culture. The land area used for fish culture is increasing (now 10,000 ha or more). In the river basins and in the dammed sections of the Danube, fish culture is intensive. Production is from 1,000 to 2,000 kg/ha/year. In the delta region, fish culture is also combined with reed culture, but then fish production is not more than 150 kg/ha.

In many cases, fish culture is done in Romania by state farms. Agricultural production cooperatives also carry out fish culture but only on a small scale.

Spain

In Spain, practically all fish culture for re-stocking natural waters is governmental, but there are some fish culture establishments in the zone of "Extremadura" where tench (Tinca sp.) is cultivated in small ponds.

On 4 June 1965 the Spanish Government approved a joint development plan for agriculture and fish farming for three years (1965-1967). It should greatly stimulate development of fish culture in warm-water ponds and rice fields.

Yugoslavia

Intensive fish culture is done commercially in Yugoslavia through Government enterprises. Feeding and fertilization are done. Carp is the main species cultivated. Tench (Tinca tinca), pike-perch (Lucioperca lucioperca) and sheath fish (Silurus glanis) are also cultivated but represent only 10 percent of total production.

6 FEEDS AND FEEDING

Belgium

Artificial feeding is practised for carp and roach (Rutilus arcasi) culture. Often corn is used and to a lesser extent, other cereals. Mixed feeds are also manufactured in granulated form for cyprinids and to a lesser extent for salmonids. Corn is imported but the other cereals and mixed feeds are produced in Belgium.

France

Artificial feeds are not used in France, except in a few cases where crushed wheat and barley are used.

Greece

Except for experimental purposes artificial feeds are not used in brackish water.

Israel

Artificial feeding is practised in carp fish farms. Fortunately, the carp is not choosy and cheap grain or second or third grade oil cakes make feeding profitable and increase yields. The feed is distributed once daily in the morning with a mechanical distributor.

The amount of feed used depends upon the fertility of the pond and the size of the fish. In well-fertilized ponds, the average food coefficient is about 1:2.5 - 3.1, that is to say that 2.5 - 3.1 kg of feed are needed to produce 1 kg of fish. This coefficient represents an average; throughout the growing season this ratio varies according to the size of the fish. A 100 g fish has a coefficient of 1:1, whereas a 500 g fish has a coefficient of 1:3.5.

The amount of feed is determined every two weeks when through fish sampling, growth rates are checked and, in accordance with the right coefficient, the final amount of food for the next two weeks is determined. Some farmers do the sampling once a week.

Feeding stops when water temperature goes below 15°C. The exact gain obtained by feeding is hard to determine, but there is good indication that of 2,000 kg of fish obtained from a hectare, about 400 kg come from the natural food of the pond, 400 more from fertilizers and an additional 1,200 from artificial feeding. These figures will probably vary for different ponds, depending on their natural fertility.

Israel has embarked recently on a research program with the aim of developing a better balanced feed with higher protein content. This is expected to give higher yields.

Netherlands

In the Netherlands, breeding stations have adopted supplementary feeding for carp. It consists mostly of grains, as a rule rye or barley, but experiments have been started with mixed feeds of various kinds of grains such as rye, wheat and barley. The average feeding for carps that are a few years old amounts to 1,600 kg of rye per ha for the period May to September inclusive. Supplementary feeding for one-year-old carp amounts to 1,100 kg of barley per ha for the period August to October inclusive.

The following results were obtained with the feeding rates given above:

Yields obtained

Year class	Amount of feed		Conversion rate	
	g per fish/year	per ha/year	relative	absolute
1 - 2	700	1,400 - 2,100 kg	2	4
2 - 3	2,100	1,100 - 1,300 kg	2.5	5

Feed is easily obtainable and is supplied every week. The price per 100 kg is approximately fl.31 - fl.35 1/.

Pike fingerlings are produced in concrete basins or small ponds by feeding with live zooplankton caught in lakes or in production ponds. The system is still under development, particularly with a view to mechanization.

Poland

The main feeds used for carp in Poland are maize, sorghum and of lesser importance, rye, lupine and waste products of flour mills. The conversion factors, i.e. ratio of the amount of food to net increase in weight of stock are:

Maize and sorghum K_1 (one-year-old carp) - 4
K_2 - 5
K_3 - 6

For lupine it is about 20 percent lower

The price of 9 kg sorghum is equivalent to that of 1 kg carp

Romania

A mixture of sunflower oil cake, corn and wheat waste is used in the manufacture of artificial feeds. The conversion rates are the following: (unit weight of feed to obtain unit weight increment in fish) 3.5 kg in farms where trouts are raised for the market and 2.5 kg in farms where trouts of one summer are raised. In 1964, granulated feed was manufactured following an original recipe and the conversion rate was less than 2 kg.

Spain

The fresh-water species cultivated in warm water in Spain are the royal carp, the black-bass and the pike; all for stocking of natural waters. Tench (Tinca tinca) is raised in lagoons on a small scale for local consumption.

In carps less than one year old, the percentage of early losses is fairly high, but this percentage decreases later, more so in cases where supplementary food is used. For carps more than one year old, the mortality rate is very small, but in all cases supplementary feeds are used.

1/ fl.3.64 = 1 U.S. dollar

For the feeding of black bass at the fry stage, plankton cultivated in ponds is used; production of zooplankton is increased by adding superphosphate and fish meal. Black bass are fed with gambusia (Gambusia holbroockii) and roach (Rutilus arcasi) and only in certain periods, when it is difficult to find sufficient amounts of these fish, are granulated feeds used as in trout culture.

Yugoslavia

In Yugoslavia, granulated feeds, mostly corn, are used. Sometimes low quality wheat, barley, lupine etc. are also used. Previously, grains were ground and kept in water for 24 hours and then fed to the fish; lately, these artificial feeds are fed to the fish in the dry state.

The conversion rate is 2 or 3 depending mainly on the quality of the feed and the density of stocks. The cost of feed in 1964 ranged from 50 to 70 dinars[1] per kg.

7 FERTILIZATION

Belgium

Ponds on fish farms are often fertilized, more so if the soil is poor and fed with water having little alkaline reserve. Lime, potassium fertilizers and organic manure are used.

France

Fertilization of ponds is carried out only since about 50 years, while the drying up of the ponds and the system of rotating the crops was a traditional method inherited from the Middle Ages in certain regions (Brenne, Dombes, Forez).

The use of lime, in the form of carbonate and of agricultural lime, has contributed greatly to increasing the yields of the acid ponds of Sologne and Brenne, as well as the quality of the fish produced. Usually, 200 kg/ha of lime is used, this is usually insufficient. Certain ponds are fertilized with granulated quick lime.

The application of phosphates in ponds is well known. Phosphate slag, superphosphate and hyperphosphate are most commonly used. The quantities used are often insufficient but the positive results encourage the farmers to fertilize regularly since the end of World War I at the rate of 17 to 150 kg/ha. Potassium and nitrogenous fertilizers are seldom used in France. In 1965, trials with liquid fertilizers seemed to give satisfactory results.

Greece

Experiments in the use of fertilizers in fresh and brackish water are now under way.

Israel

Experiments in Israel have shown that fertilization enables a denser stocking rate and a better utilization of the additional feed. Experiments proved that natural fertility can produce 200-400 kg/ha of fish. By adding fertilizers without supplementary food, production can be raised to 800-1,000 kg/ha.

1/ 12.50 dinars = 1 U.S. dollar

In most of Israel waters the nitrogen : phosphorus ratio has been found to be from 90:1 to 325:1. This means that with the supply of fresh water, a considerable amount of nitrogen is added to the pond. The other sources are the blue-green algae which is abundant in most fish ponds of the tropical regions, and which can fix considerable quantities of nitrogen from the air.

Fertilization experiments have shown that four parts of nitrogen to one part of phosphorus is the desirable ratio for good growth of plankton. In the light of these considerations, and as a result of years of experimentation in Israel, a fortnightly dose of 600 kg/ha of a 20 percent nitrogen containing fertilizer (ammonium sulphate) is recommended. Two to three weeks after filling the pond with fresh water, and in high summer (the middle of June to the middle of September) when blue-green algal blooms appear, nitrogen fertilization can be stopped.

Netherlands

Practically all the ponds in the country are fertilized yearly according to the following scheme:

Soil	Fertilization (March)	Additional fertilization (June-August)
Sand	600-1,000 kg calcium carbonate 300-400 kg superphosphate	2 x 75 - 2 x 100 kg superphosphate
Mud	600-1,000 kg calcium oxide 300-500 kg basic slag	2 x 75 - 2 x 100 kg calcium oxide or ammonium sulphate

Fertilization is carried out to obtain a dense growth of blue-green algae. Organic fertilizers are now increasingly used in breeding ponds. About 5 m^3 chicken dung per ha is milled into the bottom to get a quick development of zooplankton. Fertilization results in 50 to 150 percent increase in production, with an average of 80 percent.

The costs of the fertilizers per 100 kg are the following:

CaO	(Calcium oxide)	- fl 52
$CaCO_3$	(Calcium carbonate)	- fl 42
Psup	(Superphosphate)	- fl 125
Psl	(Basic slag)	- fl 90
$(NH_4)_2SO_4$	(Ammonium sulphate)	- fl 210

Poland

Ammonium sulphate, ammonia liquor and superphosphate are the commonly used fertilizers. Experiments are being carried out with ammonium carbonate and urea. Organic fertilizers (manure and "green manure") are applied to fry ponds which are used for one month only. Calcium is widely applied in ponds in Poland to improve the bottom soil, increase pH and for sanitation purposes.

Romania

Productivity varies according to the quality of the soil and water as well as the quantity and quality of artificial feeds used. In special cases, in limited areas, as much as 1,500 kg/ha/year were obtained without artificial feeding and more than 10,000 kg/ha/year with feeding. Generally, the following yields are obtained: (i) 100-150 kg/ha/year in fish-cum-reed culture without feeding; (ii) 350-500 kg/ha/year without feeding, and (iii) 1,000-2,000 kg/ha/year with feeding.

Spain

Fertilizers (superphosphate and fish meal) are used only for the production of zooplankton, especially daphnia and artemisia.

Yugoslavia

One tenth of the ponds in Yugoslavia use organic and mineral (lime, nitrogen and phosphate) fertilizers. On the average, 400 kg of phosphate are applied per hectare. When the soil is acid, 500 kg of lime per hectare are applied. Nitrogen fertilizer is used in smaller quantities than others at less than 200 kg per hectare. Small ponds, especially rearing and spawning ponds, receive organic fertilizers.

8 STOCKS

Belgium

Fish culturists produce fry of carp, roach and tench in their own ponds. Pike fry are obtained from specialized fish culturists who may import fertilized eggs from abroad. Fertilized eggs or fry of pike-perch as well as eels are imported from abroad.

France

Fish culturists obtain their stocks from their own production; they do not buy them nor do they collect them from natural waters. Efforts are being made to improve the quality of carp through selection. Supply is sufficient and no new species have been introduced. In a few ponds, black bass and pike-perch are used as predators instead of pike.

Greece

Stocking of brackish-water lagoons is done naturally with fish coming from the sea or by the gathering of fry in other regions.

Israel

In Israel, fish culturists usually raise their own stocks or buy them from cooperatives that specialize in rearing fingerlings for stocking purposes. Selective improvement is practised.

Italy

Certain fish farms specialize in raising carp and tench for stocking purposes. Most of them are found in northern Italy, but two are located in central and southern Italy. Fish is sold at those establishments, but the production falls short of demand. To stock brackish-water ponds fry are caught at the mouths of canals and rivers on the coast.

Netherlands

Carp stocking material is produced in the fish culturist's own farm. Pike spawners are caught in natural public fishing waters and the eggs are fertilized artificially. Likewise, pike-perch are caught each year in public fishing waters for breeding.

Unlike pike and pike-perch, selective breeding is possible with carp. The selected system applied consists mostly in eliminating the undesirable hereditary characters. Cross-breeding is done with wild carp, which at present are tested for their utility in sport fishing.

Poland

Stocks of carp are usually obtained from pond-reared spawners. Small private farms buy fingerlings at the state farms.

Tench, pike and pike-perch stocks are mostly derived from pond-reared spawners. Abramis brama, Gardonus rutilus (Rutilus rutilus), Vimba vimba, Esox lucius, Stizostedion lucioperca stocks for stocking natural waters, are collected from nature.

Hypophthalmichthys molitrix, Ctenopharyngodon idella and Aristychthys nobilis are imported from Russia since 1964.

Rearing experiments with carp and crucian carp hybrids have been initiated.

Romania

Stocks of carps one year old, 20 to 25 days old or, more rarely, 5 to 10 days old are obtained either from rearing ponds in the fish farms or from state farms. Small carps, one summer old, are sold at eight lei [1/] a kg.

Yugoslavia

Most fish culturists raise their own stock of carp. Selection is practised in an empirical manner.

9 GOVERNMENTAL ACTIVITIES AND CONTROLS

Governmental assistance in Western European countries and Israel is usually limited to the operation of research institutes and small experimental stations. In Spain, for instance, the fish culture service has offices all over the country and each one of these has a team of technicians whose job is to solve local fish culture problems.

Limited financial assistance is given in France and Italy.

In Eastern European countries, such as Poland, Romania and Yugoslavia, governmental activities and controls in the field of inland fisheries and fish culture are many-fold. General development plans are prepared and implemented by the governments. In Yugoslavia the State finances the building of ponds through its bank and helps cooperatives in planning production. It further makes the laws and regulations concerning fish culture. In Poland regulations have been enacted to control the spread of dropsy in carps.

1/ 12 lei = 1 U.S. dollar

10 PROBLEMS AND PROSPECTS

The rapid progress of industrialization has reduced the quantity and quality of water available for pond fish culture. In Poland for instance, the water deficit (and the resulting shallow ponds) has become a problem. In Italy also the supply of fresh water is limited and efforts are made for increasing the use of brackish water.

In the Netherlands and Spain there is a scarcity of stocking material. Throughout the region, spreading fish diseases have caused considerable concern. Lack of a sufficient number of qualified persons remains a widely felt handicap to fish culture development. A number of measures are being taken to solve these problems. In Israel, research programs concerning fish diseases have been intensified and a more balanced food with higher protein content is being developed. In Poland, recent measures such as the wide use of extension service at various levels has given encouraging results. Feeding, fertilizing and regulating stock density have made it possible to increase carp production from 10,000 to 15,000 tons per year.

In Yugoslavia, the 1964-70 Program for the Development of Fish Culture aims at an increase in production to 40;000 tons a year. In Romania, fish culture in the barrage zones of the Danube, in the delta and in the marsh areas of the river basin is planned to be extended to a very considerable extent.

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I/RR-6

THE STATUS OF WARM-WATER FISH CULTURE IN AFRICA

by

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THE STATUS OF FISH CULTURE IN WARM-WATER PONDS IN AFRICA

Abstract

Fish culture is not indigenous in Africa. Some cold-water fish culture developed between the wars. The introduction of warm-water pond fish culture, mainly with tilapia, took place principally between 1953 and 1960.

Fish culture in Africa is carried out mostly on subsistence level, as a spare-time occupation of agricultural farmers. The mixed method is the most commonly used in fish culture. The ponds contain various age-groups and sometimes different species of fishes. Breeding and rearing are done simultaneously in the same ponds. Larger fish are fished out with nets during the culture period and the total stock harvested by draining. An experimental fish farm for brackish-water pond fish culture has been established in the Niger Delta with the assistance of FAO. Rice-field fish culture has not yet become popular and it is practised only in a small area of Madagascar.

Eighteen species of tilapia have been tried in Africa, but only a few are used in actual practice. Different food habits require different culture and feeding methods. Feeding and weed control are neglected by many African fish culturists, and this results in low production. Fertilization of ponds is rarely done.

Carp culture is at its very beginning in Africa. Other African and exotic fishes have been tried. Heterotis niloticus is used to a small extent with good results. Predators kept for tilapia population control have gained some importance e.g. Lates and Micropterus.

Fish parasites and diseases have not yet gained practical importance in Africa. Fish culture could spread those human diseases requiring aquatic animal vectors. Malacophagous fishes have been used successfully for the control of vector snails of schistosomiasis in experiments. Mosquito-transmitted diseases do not become a problem in well-kept ponds.

Economic data on investment costs and recurrent expenditures in home-pond fish culture is rare. The few figures available cannot be used for general conclusions as local conditions vary greatly.

After an explosive development, fish culture in Africa has come to a standstill or even a decline. Over-population in ponds and the resulting small size of fish causes a lack of interest in fish farming. Mixed culture is genetically anti-selective. The introduction of methods eliminating over-population would require a considerable change of the present structure of fish culture. Suggestions are made to improve the extension service, to train fish farmers, to introduce professional fish farming, to create an infrastructure for large-scale commercial fish culture economy and to improve culture and management methods.

I/RR-6

SITUATION DE LA PISCICULTURE EN ETANGS A TEMPERATURE ELEVEE EN AFRIQUE

Résumé

An Afrique, la pisciculture est une activité d'importation. L'élevage de poissons en eaux froides s'est pratiqué dans une certaine mesure entre les deux guerres, mais c'est surtout entre 1953 et 1960 que s'est dévelopée la pisciculture en étang à eaux à température élevée, intéressant principalement les tilapias.

Ce sont surtout les agriculteurs africains qui pratiquent, à temps partiel, une pisciculture de subsistance. L'élevage mixte est le plus employé, l'étang renfermant non seulement divers groupes d'âge, mais parfois différentes espèces. Reproduction et élevage ont lieu simultanément. On prélève au filet en cours d'élevage les gros sujets, et la totalité du stock est récoltée au moment de la vidange. Un établissement piscicole expérimental pour la pisciculture en eaux saumâtres a été créé dans le delta du Niger avec l'assistance de la FAO. La rizipisciculture n'est pas encore entrée dans les moeurs, et n'est guère pratiquée que dans un secteur restreint de Madagascar.

Pour ce qui est des tilapias, les essais piscicoles ont porté sur 18 espèces, mais quelques-unes seulement sont utilisées dans la pratique. Etant donné les différences dans les habitudes alimentaires de la population, il n'est pas possible d'appliquer les mêmes méthodes d'élevage ou de nourrissage. Nombre de pisciculteurs africains négligeant l'alimentation d'appoint et la lutte contre les plantes aquatiques, le niveau de la production s'en ressent. La fumure des étangs est rarement pratiquée.

La carpiculture ne fait que commencer en Afrique. Des expériences ont été faites avec d'autres poissons, africains ou exotiques. Heterotis niloticus, utilisé à faible échelle, donne de bons résultats. Les Lates et les Micropterus, prédateurs élevés pour la limitation des populations de tilapias, ont pris une certaine importance.

Sur le plan pratique, parasites et maladies des poissons ne posent pas encore de problèmes en Afrique. Il se peut que l'extension de la pisciculture diffuse certaines maladies humaines transmises par des vecteurs aquatiques. De bons résultats ont été obtenus lors d'essais d'utilisation de poissons malacophages pour lutter contre les escargots, vecteurs de la bilharziose. Si les étangs sont bien entretenus, le problème des maladies transmises par les moustiques ne doit pas se poser.

On manque de données économiques sur les dépenses d'investissement et les dépenses renouvelables en matières de pisciculture familiale. Les quelques chiffres disponibles ne permettent pas de formuler des conclusions générales, les conditions locales étant très diverses.

Après avoir pris un départ en flèche, la pisciculture africaine a cessé de progresser, ou même accusé des reculs. La surpopulation des étangs, entraînant la récolte de poissons de petite taille, décourage les pisciculteurs. La culture mixte va à l'encontre de l'amélioration génétique. Pour mettre en oeuvre des méthodes visant à éliminer la surpopulation des étangs, la structure actuelle de la pisciculture africaine devrait être considérablement modifiée. L'auteur présente des suggestions intéressant les domaines suivants: amélioration des services de vulgarisation, formation des pisciculteurs, mise au point d'une pisciculture professionnelle, création de l'infrastructure nécessaire à une pisciculture commerciale à grande échelle, perfectionnement des techniques d'élevage et d'aménagement.

Extracto

La piscicultura no tiene carácter indígena en Africa. Entre la primera y segunda guerra mundiales se desarrolló en cierto grado la piscicultura en aguas frías. La introducción de la piscicultura en estanques de agua templada, principalmente con tilapia, se verificó principalmente entre 1953 y 1960.

La piscicultura en Africa se lleva a cabo principalmente al nivel de subsistencia, como ocupación accesoria de los productores agrícolas fuera de su tiempo de trabajo. El método mixto es el más corrientemente utilizado en la piscicultura. Los estanques contienen varios grupos de edad y a veces diferentes especies de peces. La producción de huevos y alevines y la cría de los pequeños peces se efectúa simultáneamente en los mismos estanques. Los peces más grandes se capturan con redes durante el período de cultivo, y la totalidad de la producción se recoge mediante desecación del estanque. Con ayuda de la FAO se ha establecido en el delta del Níger una granja piscícola experimental para el cultivo de peces en estanques de agua salobre. La piscicultura en arrozales todavía no se ha hecho popular y solamente se practica en una pequeña zona de Madagascar.

Se han ensayado en Africa 18 especies de tilapia, pero en la práctica real se utilizan pocas de ellas. Los distintos hábitos alimentarios exigen diferentes métodos de cultivo y de alimentación. Los piscicultores africanos descuidan la alimentación artificial y la lucha contra la vegetación acuática y esto da por resultado una producción baja. Raramente se practica la fertilización de los estanques.

La carpicultura está en sus comienzos en Africa. Se han ensayado otros peces africanos y exóticos. Se utiliza en pequeño grado Heterotis niloticus con buenos resultados. Han adquirido cierta importancia especies predadoras mantenidas para limitar la producción de tilapia como Lates y Micropterus.

Los parásitos y enfermedades de los peces no han alcanzado todavía importancia práctica en Africa. La piscicultura podría difundir estas enfermedades humanas que requieren vectores acuáticos animales. Los peces malacófagos se han utilizado con éxito en experimentos para combatir los caracoles vectores de la esquistosomiasis. La enfermedades transmitidas por los mosquitos no constituyen un problema en los estanques bien mantenidos.

Es rara la existencia de datos económicos sobre gastos de inversión y gastos continuos en la piscicultura en estanques familiares. Las escasas cifras de que se dispone no pueden utilizarse para deducir conclusiones generales ya que las condiciones locales varían ampliamente.

Después de un desarollo explosivo, la piscicultura en Africa ha pasado a un período de estabilización o incluso de descenso. La superpoblación de los estanques y la consiguiente disminución del tamaño de los peces ha dado por resultado una falta de interés en el cultivo piscícolo. La piscicultura mixta es genéticamente antiselectiva. La introducción de métodos que eliminen la superpoblación de los estanques exigiría un cambio considerable de la estructura actual de la piscicultura. Se hacen sugerencias para majorar los servicios de divulgación, capacitar a los piscicultores, introducir la piscicultura profesional, crear una infraestructura para una piscicultura comercial en gran escala y para majorar los métodos de cultivo y de explotación.

1 THE REGION

The African Region of FAO comprises the major part of the African continent, Madagascar and the neighbouring islands in the Atlantic and Indian Ocean, except Libya, Somalia, Sudan and Egypt (U.A.R.) which countries are included in the Near East Region.

The countries and territories in the region are: Algeria, Angola, Basutoland, Bechuanaland, Burundi, Cameroon, Canary Islands, Cape Verde Islands, Central African Republic, Congo (Brazzaville), Congo (Leopoldville), Dahomey, Ethiopia, Fernando Po, Gabon, Gambia, Ghana, Guinea, Portuguese Guinea, Ivory Coast, Kenya, Liberia, Madagascar, Mozambique, Nigeria, Niger, Réunion, Rhodesia, Rio Mundi, Rwanda, Senegal, Sierra Leone, French Somalia, South Africa, South-West Africa, Spanish Sahara, Swaziland, Tanzania, Republic of Tchad, Togo, Tunisia, Uganda, Upper Volta and Zambia (minor islands are omitted).

Fish culture is practised on the continent, in Madagascar, Mauritius and Réunion.

The central part of the region is in the tropical zone and extends into the subtropical zones. It covers all known tropical climatic zones from desert climates to extremely humid areas.

Reliable perennial water resources for fish culture are numerous, mainly in the humid areas, between about 10°N and S of the equator and in Madagascar.

The water quality is normally suitable for fish culture. The pH of the waters (as far as known) is mostly near neutral or slightly below. Extremely acid and alkaline soils and waters are rare. The calcium content and the alkaline reserve are low in many West African waters so that considerable daily pH fluctuations can occur. Phosphate seems to be, like elsewhere, the most important minimum substance. In some waters of West Africa sulphate can go down to minimum values and may then act as limiting factor for production. Iron content can sometimes be a handicap. The environmental factors for fish can change within relatively small areas. Generalizations for such a vast continent are therefore not possible.

2 DEVELOPMENT OF FISH CULTURE IN THE AFRICAN REGION

Fish culture is not indigenous in Africa. It has been introduced everywhere. Introduction of foreign fishes into natural waters and stocking of artificial waters are not considered in this report as fish culture.

Production of fish in ponds started in Africa with the introduction of cold-water fish culture between the two world wars.

Trout hatcheries, mainly for stocking sport fishing waters, have been established in higher altitudes in Morocco (the first in 1924), South Africa, Kenya, Réunion and Basutoland. Production of food fish is normally not done in these hatcheries. Pike hatching for river and lake stocking started before the second world war in 1939 in Morocco (Chapuis, 1959).

The first and only modern carp farm was built in 1954 in Panyam, Northern Nigeria. Initially it cultivated tilapia but it took up carp farming in 1959 (Anon., 1963).

The use of tilapia for fish culture has been suggested by Monod since 1925 (Bard, 1962a and b). Systematic studies on the possibilities of warm-water pond fish culture with Tilapia started in 1946 in Katanga, Congo (Leopoldville), in 1948 in Cameroon and in 1949 in French Equatorial Africa (now Congo Brazzaville). Measures to introduce Tilapia were not undertaken however before 1949, 1952 and 1953 respectively in these countries. Details of the introduction of pond fish culture in various African countries are given in Appendix I.

3 THE CHARACTERISTICS OF FISH CULTURE IN AFRICA

Fish culture has been introduced into the region on the initiative of governments, mainly to improve the diet of the local population. The "colonial administrations" established fish breeding centres. These were used as models carrying out experiments, demonstrations, training and distribution of fry to private farmers. They did not produce fish for consumption. In certain areas farms were built and operated under the supervision of the government centres for the production of young fish.

Private fish farming developed under the guidance of these centres. African fish culture of today is principally of the home-pond subsistence type, managed as a part-time occupation of farmers. Thousands of such home-ponds have since been built (App. I). A small number of large fish farms were established in the former Belgium Congo, the Rhodesias and in Mozambique by European settlers, larger schools, missions and private companies, mainly to produce fish for their own use.

Private commercial fish farming has not developed in the African region. Occasionally home-pond owners make a small cash income from the sale of surplus production, particularly in Madagascar and Uganda. The Panyam Fish Farm in Nigeria was established as a commercial project, but has now been converted into a fry production centre.

4 METHODS OF FISH CULTURE

4.1 Tilapia culture

4.1.1 Pond construction

Fish breeding centres and the few large fish farms in Africa mostly have well laid out pond systems.

Numerous privately owned tilapia home-ponds are either constructed by excavation, by damming small streams in valleys, by diverting water from streams or as contour ponds along streams.

Dug-out ponds are normally very small, about 100 to 500 m^2 and about 1 m deep. Dammed ponds can be larger and vary in size and depth according to the bottom relief; but exceed rarely 1 ha. Larger dams in which Tilapia may be reared are often constructed for purposes other than fish culture. Extremely small ponds of only a few square meters have also often been constructed (Bard, 1962b; Kiener, 1963).

The size of the ponds influences growth. Tilapia claims, obviously, less space than carp and can grow in very small ponds. According to Bard (1962b) greater depth of ponds delays the maturity of T. mossambica and in deeper ponds this fish grows to a larger size. Dug-out ponds usually cannot be drained. Many dammed ponds are not levelled carefully and have no drainage facilities so the dykes have to be cut open for drainage.

In Madagascar it has become common to have storage tanks for storing small fishes, during the draining period, for restocking. Monks are built mainly for larger ponds. Often little attention is paid to water-supply control arrangements and many ponds are endangered by floods. In government farms and in larger dams protection against wave action is achieved by planting grass (Paspalum) (Huet, 1957). Such provisions are normally not made in home-ponds.

4.1.2 Culture methods

Tilapia culture developed in Africa empirically following the management measures comparable to the ancient "femel" culture of carp in mediaeval Europe.

Three types of tilapia culture are recognized (Bard, 1962c; Huet, 1957 and others):

(i) The mixed method or method of culturing mixed age classes ("femel" culture in carp farming). The same pond is used for both propagation and production. It is heavily stocked with different species and age groups of tilapia. The population propagates and grows quickly to a size near to the capacity of the pond. This level is kept up by periodic fishing starting three to four months after stocking. After eight to 12 months the pond is emptied and all fish are taken out. A new stock of young fish is stocked after refilling. One gets enough young fish for restocking. This is the most common method in Africa. Crops consist of fish of all sizes. Insufficient fishing results in over-population and stunting.

(ii) Rearing in age groups. The pond is stocked with one age group. After one reproduction the pond is emptied, the larger fish are removed and the young ones are used for restocking. In this method the individual fish grows faster (Kiener, 1957b). The total production is smaller than that in the mixed method (Bard, 1962c) because a variety of sizes (and species) utilizes the available food better. The crop consists of fish of nearly equal size. This method is not popular in Africa. It is obvious that it can only be implemented where water conditions allow refilling of the pond at any time.

(iii) Rearing with reproduction control. This type of tilapia culture makes it possible to avoid the danger of over-population in the ponds. Three methods have been developed for this purpose:

(a) Use of predators. Predatory fish are stocked in the pond to keep down the population of young tilapia.

Hemichromis fasciatus, Lates niloticus and Micropterus salmoides (black-bass) are used for this purpose in practice. Many others have also been tried (Appendix IV). The method is not quite reliable and satisfactory. The predation can be complete and no young fish may be left for restocking. On the other hand, it may be insufficient and the danger of over-population may persist. According to Lemasson (1960b) predators can change the proportion of species in mixed culture. The method is followed in farmers' ponds in Cameroon (with Hemichromis as predator), Madagascar (with black bass) and Nigeria (with Lates), but it is not yet popular in most other countries.

(b) Sexing. For most Tilapia species it is possible, although not always easy, to differentiate the sexes at an early stage. The pond is stocked only with young males, which grow faster than females. However, if a few mistakes are made and a few females are introduced in the pond, it is sufficient to spoil the results. This method has been adopted only by very few experienced farmers.

(c) Hybridization. Following hybridization experiments with Tilapia mossambica in Malacca, many combinations of Tilapia species have been tried in experiments in Africa (Appendix III). All of them resulted in an unequal sex ratio but rarely in 100 percent mono-sex hybrids. The sex ratio varies in experiments with the same species. The hybrids appear to be fertile. Therefore sexing is still necessary.

An FAO expert (FAO/UN, 1965) working in Uganda has obtained in repeated experiments 100 percent male hybrids from the combination of the male Tilapia mossambica and the female T. nilotica. Large-scale culture of hybrids in private farms has yet to be undertaken.

4.1.3 Cultivated species of Tilapia

The Tilapia species cultured are listed in Appendix II under the family Cichlidae. There is considerable confusion in their systematics and many workers have pointed out the need for a taxonomic revision of the genus (Bard, 1962c; Huet, 1957).

It has been shown that in some West African countries the fish cultivated for years as T. melanopleura was actually T. zillii (Bard, 1962c). In East Africa T. andersonii seems to have been confused sometimes with T. macrochir.

Racial differences seems to occur in widely distributed species. In cross breeding experiments of T. mossambica in Malacca where the species was introduced earlier, with specimens subsequently imported from Africa, the two stocks showed the characteristics of two different species, producing "hybrids" with a very unequal sex ratio. In experiments in West African countries (Cameroon, Ivory Coast) differences have been discovered between local T. zillii and the one imported from the Congo. The Bouaké Station in Ivory Coast considers these strains as separate and differentiates Tilapia zillii (local) and T. zillii (Congo) in their publications (Lessant, 1961). Whether these are different races or even different species must be decided by taxonomists.

The Tilapia species differ considerably in food and breeding habits. All of them are monogamous. There are substrate-breeders and mouth breeders, and variations within these groups also occur.

Tilapia melanopleura and T. zillii are mainly herbivorous though not always. All other species are microphagous or non-herbivorous-polyphagous. Adult T. nilotica can become predatory (Mrogo, 1961). Similarly T. melanopleura is reported to feed on eggs and fry.

All Tilapia species are tropical warm-water fishes. T. galilea and T. zillii are indigenous in the lowlands of Morocco. Higher altitudes in inner Africa, where the climate becomes subtropical in character, with distinct cold seasons, are not suitable for Tilapia culture. Difficulties of breeding Tilapia in higher altitudes in Uganda (about 2000 m) led to the introduction of carp culture in these areas. Kiener (1963) reports that the production per hectare of tilapia decreases with increases in altitude and varies with species utilized in Madagascar as follows: (i) in coastal zones near sea level T. mossambica and T. nilotica - 5 to 6 tons/ha; (ii) in middle altitudes T. macrochir and T. zillii - 3.5 to 4.5 tons/ha; (iii) on the plateau of about 1,000 m all species - 3 to 3.5 tons/ha; (iv) above 1,500 m only T. melanopleura - 2 tons/ha. In Zambia (Meecham, 1962) T. andersonii breeds only once a year, which might also be explained by the high altitude and the change of seasons.

Little attention has been paid in practical fish culture to the climatic requirements of different Tilapia species in countries other than Madagascar.

Most Tilapia species seem to be rather euryhaline. T. mossambica and T. nilotica can be cultivated in brackish water of the mangrove area (Kiener, 1963). Tilapia heudelotii is indigenous in the mangrove area of Nigeria (FAO/UN, 1965).

The growth rate, maximum size and quality of the flesh vary among species of Tilapia. The favoured species for fish culture in Africa are: T. macrochir, T. melanopleura, T. mossambica, T. nigra, T. nilotica and T. zillii. T. galilaea and T. heudelotii are considered to be slow growers (experiments at Panyam Fish Farm in Nigeria at about 1,000 m) (Maar, 1960b). T. heudelotii is said to have a poor taste (Meecham,1962).

4.1.4 Fertilization

In experiments at many stations it has been proved that fertilization of ponds with manure and mineral fertilizers can increase tilapia production considerably. According to Wurtz (FAO/UN, 1961) tilapia ponds do not respond as well as carp ponds to fertilization. Cow dung has been found to have less effect on tilapia production compared to that of carp (Mortimer, 1962; FAO/UN, 1961). Most mineral fertilizer experiments have been carried out with commercial fertilizers containing phosphates. The effects of the various components (ions) do not seem to have been checked and their fertilizing qualities have been ascribed to phosphate. Nitrate, ammonia and potassium fertilizers are recommended occasionally. Lombard (1960) could quadruple the production of T. mossambica with lime only. Liming before manuring and mineral fertilizing is rarely recommended in Africa (e.g. Bard, 1962b; Mortimer, 1962; FAO/UN, 1961).

In some of the larger fish farms of Congo (Leopoldville) and Mozambique manure has been used regularly (Huet, 1957; Costa, 1960). Mineral fertilizers are not easily available in the region.

Fertilizing is normally not done in home-ponds. Because this type of culture is based mainly on artificial feeding, Schirlé (personal communication) recommends against the use of fertilizers on account of the cost involved and the uncertainty of their beneficial effects in small ponds. The raising of pigs or ducks near fish ponds for the purpose of fertilizing ponds has been tried on an experimental basis in Ghana (van der Lingen, 1960).

4.1.5 Feeding

As tilapia in small ponds require intensive feeding, experiments have been conducted with a variety of locally available materials (Appendix IV). Leaves and grass are the most easily available feeds, but it is obvious that daily feeding with them is only possible in small home-ponds. Large farms would need large quantities of fodder which cannot be obtained daily from the agricultural fields.

For better utilization of the natural food production including plankton, mixed culture with herbivorous and microphagous species is recommended and has become popular in many areas.

It appears that the fish farmers in Africa use mainly the leaves of cultivated plants for feeding fish and do not feed the non-herbivorous species. Uneaten plants decay and increase the production of plankton and other food organisms. A list of feeds used or recommended for tilapia feeding is given in Appendix IV.

According to Kiener (personal communication) the food-coefficient of most leaves used for herbivores may be in the order of 20:1. It may vary considerably according to the plants used and to the growth stage and age of the leaves. In Congo (Brazzaville) (Anon., 1954) the food coefficient of food other than leaves for tilapia is estimated to be 6:1, but this conclusion does not appear to be supported by critical experiments.

As in Africa animals are normally not fed by man; it is difficult to induce the farmers to feed fish. In numerous home-ponds, feeding is not done at all or at least not regularly. The fact that feeding is neglected is often the reason for poor results and consequently the loss of interest in fish farming.

4.1.6 Weed control

Herbivorous tilapia suppress development of algae and submerged soft weeds. However they do not destroy all water plants (Appendix IV) and mechanical weed destruction is, therefore, necessary as well. Many ponds have deteriorated because weed control has been neglected. In Senegal weed control with the sea-cow, Trichechus senegalensis has been tried in irrigation systems (Bard, 1962c). Weed control with nutria, Myocastor coypus, done in Europe in small fenced ponds, has been recommended and successfully tried in Cameroon (Bard, 1962c; Ehrlich, 1957). However, this or chemical methods of weed control have not been adopted elsewhere in Africa.

4.2 Carp culture

Carp was probably introduced in Africa before 1859. It was in use in the Cape Province of South Africa in 1896 for stocking natural waters (Maar, 1960). Because of the alarming reports of carps spreading in natural waters in North America and in South Africa, the introduction of carps was banned in most English speaking countries and in Congo (Leopoldville). Stocks were even destroyed (De Bont, 1949; Coche, 1960; Maar, 1960b). Only in the last six to seven years has carp culture gained acceptance again in Africa. Carp farming was started in the Panyam Fish Farm in Nigeria in 1959 with carps of Yugoslavian and Israeli origin. In Rhodesia and South Africa (Transvaal) European strains of carps from Bavaria were introduced for experimental purposes in fish breeding centres in 1958 and 1959 respectively. Carp was introduced in Ghana in 1962 and in Eastern Nigeria in 1963 from the Panyam Fish Farm for experiments. Uganda started experimental culture of carps of Israeli origin in 1961.

Even now prejudices against carp culture exist. As the introduction of carp was done during the "boom" of tilapia culture development it was not easy to rouse public interest in an exotic fish. The results of early experiments in small tilapia ponds were not satisfactory (Maar, 1960a). Sometimes the carps did not spawn in the small ponds or the spawning was comparatively poor (Kiener, 1963; Kiener and Therezien, 1958) Also the lack of experience of the "pioneers" was responsible for many failures. Adequate pond systems for spawning and for rearing carps in age groups did not exist. In the only place where they existed (Panyam) carp production was a success.

However, whereas in Europe the carp matures in the third and fourth year, it sometimes matures in the tropics in the first year, when it reaches about half a kilogram (Zwilling, personal communication). This must necessarily lead to changes in the traditional European management methods for adoption in Africa.

In the high plateau of Madagascar and Nigeria the carp has distinct spawning seasons, whereas in lower altitudes it matures and spawns at any time. The difficulties of breeding carps in tilapia home-ponds and the low fry production in the small ponds of the fish culture stations prevented carp culture from becoming important in Madagascar. Thérézien (1960 and 1963) stressed the need for larger carp culture stations specially designed for the production of fingerlings to stock home-ponds. For the various reasons mentioned above carp culture in ponds remains even now in its very beginning e.g. in Uganda.

4.3 Culture of other fishes

(i) Heterotis. Among the numerous species of fish tried in fisheries in African stations Heterotis niloticus has received special attention because of its rapid growth rate (2 to 3 kg per year) (Bard, 1960a, 1962c; Lessant, 1961). This fish does not easily propagate in small ponds. Bard (1962c) recommends propagation ponds of more than 2 ha in area. Maturity starts at 20 to 22 months. Breeding occurs throughout the year, at least in low altitudes. Fingerlings of 40 to 50 g are produced in fish culture centres to stock home-ponds. Supplemental feeding is done with rice-bran, groundnuts (Bard,1960a and 1962c), groundnut and cotton seed cakes (Lessant, 1961). The fish is not well accepted by consumers because of its taste and the numerous sharp lancette-shaped bones. Nevertheless it is being introduced in Cameroon, Ivory Coast, Nigeria (Panyam Fish Farm) and in Madagascar. In home-ponds it is raised together with tilapia. As it does not breed easily in small ponds, over-population does not seem to be a problem. Heterotis culture may assume importance in African fish culture in the future.

(ii) Citharinidae: This group of principally planktophagous fishes is common in natural waters mainly in West Africa and can be found occasionally in fish culture centres and home-ponds. It has raised great interest because of its rapid growth, which is said to be higher than that of carp (Otorubio, personal communication). However, it has not yet been possible to make these fishes reproduce in captivity and specific methods of culture have not been developed.

(iii) Black bass: In Congo (Leopoldville), Gambia and Rhodesia, production of the American black-bass (Micropterus salmoides) with the blue-gill (Lepomis) as prey has been tried but has not gained economic importance. In South Africa Tilapia sparmanii has been used instead of blue-gill. This fish does not propagate easily in Africa (Bard, 1962c; Huet, 1957; Kiener, 1963). Propagation difficulties seem to be connected with lower altitudes as they are rarely reported in higher altitudes where the fish has acclimatized itself and propagated in natural waters, e.g. Kenya, around Mount Kenya, some areas of Madagascar and South Africa. On the plateau of Madagascar black bass caught in natural waters are regularly sold in the fish markets. In the Atlas mountains of Morocco the propagation in rivers and reservoirs is not satisfactory (Chapius, 1962) and it is not yet clear whether it happens regularly.

(iv) Lates is mainly produced in fish culture centres for the control of Tilapia over-population. Propagation in ponds is often difficult. Zwilling (personal communication) succeeded in making Lates niloticus reproduce by changing the water level of the ponds according to the rhythm of the floods in the rivers. Later on, they spawned also in ponds with constant water level. It seems that Lates needs larger water areas for spawning.

4.4 Combined culture methods

Rearing tilapia and carp in the same ponds is often recommended and practised, e.g. in Madagascar and Uganda. At Panyam Fish Farm in Nigeria experiments proved that carp grows slowly when tilapia propagate in the ponds to the extent that it becomes competitive to carp. Heterotis is normally raised together with tilapia in home-ponds and there seems to be no significant competition. Citharinids can also be raised together with Tilapia.

4.5 Fish culture in rice fields

Though successful experiments have been conducted in rice field fish culture in many areas (Bard, 1962c; Chapuis, 1962; Coche, 1960: Costa, 1960; FAO/UN, 1957; Huet, 1957, 1959 and 1962; Kiener, 1957a, 1962 and 1963; Thérézien, 1960) it is rarely practised except for instance in Madagascar and Morocco. Experiments are being continued in some countries such as Ivory Coast.

In Madagascar, where rice culture is indigenous, some rice farmers have started on their own initiative to stock their rice fields with fish. Their production although large per field is "insignificant" in relation to that of the total pond fish production of Madagascar (Kiener, 1957a, 1963; Thérézien, 1960).

The following fishes have been used in rice-field fish culture: Tilapia melanopleura (Congo (Leopoldville), Nigeria, Zambia), T. mossambica (Madagascar, Mozambique, Rhodesia), T. nilotica (Tanganyika), Paratilapia pollenii (Madagascar), Cyprinus carpio (Madagascar, Morocco), Carassius auratus (Madagascar), Barbus spp. (Mozambique), Gardinus rutilis (Morocco), Tinca tinca (Morocco).

Mixed culture of carp, T. nilotica and T. melanopleura, or carp, T. macrochir, T. melanopleura and Haplochromis mellandii are often recommended (Chimits, 1955).

4.6 Fish culture in brackish-water ponds

Following small-scale experiments, an experimental brackish-water fish farm has recently been established with the assistance of an FAO expert (FAO/UN, 1965) in Buguma (Nigeria) in the mangrove area of the Niger delta. The initial experiments gave encouraging results and further work is progressing. The expert also studied the possibilities of fish culture in the lagoons of Ghana (FAO/UN, 1962). He concluded that brackish-water fish culture would probably be possible in West African lagoons and suggested further surveys and the establishment of pilot farms.

In Tunisia mullets and eels are reared in closed lagoons where stocking takes place by natural immigration. There are numerous large and practically unused mangrove swamps and lagoons all along the African coast, and there is good prospect for developing brackish-water pond fish culture in the region. Up to the present, proper brackish-water pond fish culture has not been done anywhere else in Africa apart from the pilot farm in Nigeria.

4.7 Control of fish diseases and enemies

Very little information exists on fish diseases in African ponds. Diplostomiasis of the eyes of Tilapia has been reported from Congo (Leopoldville) (Bard, 1962c). As these flukes have life stages in birds, snails and fish they can be controlled by malacophagous fishes (De Bont, 1949; Costa, 1962). Gill flukes (Dactylogyrus, Gyrodactylus) have been observed in Nigeria (Zwilling, personal communication) and Uganda (FAO/UN, 1965). The parasitic copepod (Lernaea) occurred in large numbers in Upper Volta (Bard, 1960f, 1962c).

Mvogo (1961) observed a fatal filaviasis which forms cysts at the operculum of Heterotis and describes an obviously non-fatal myxosporidiasis (similar to Myxosoma dujardini) found in Tilapia nilotica; both in Cameroon. R.H. Love (Bard, 1962c) observed a similar disease (Myxosporidiasis) in Uganda.

5 ECONOMICS

5.1 Home ponds

Very little information is available from literature on the economics of the prevailing tilapia home-pond fish culture. However, it is obvious that the development of this type of fish culture in a developing area like Africa, where capital is extremely short, was possible only because it could be done with minimal investment and recurring expenditures.

The small home ponds have usually been constructed by hand by the farmer himself, whose labour is not taken into account. Mortimer (1962) calculates the construction costs for a fenced contour pond of 1/10 acre (40.5 sq m) near Lusaka, Zambia, to be £22 to £35, estimating £7 10s to £12 for hand labour and £15 to £20 for equipment. If a tractor with dam scoop were used, earth movement would cost £15. These calculations for a developed town do not seem to be typical for areas where people still live in their traditional environment.

In Togo the labour costs for constructing a pond of about 100 m^2 are assessed to be 18,000 Frs CFA ($72,00) (B. Allsopp, unpublished manuscript).

The value of the fish crop cannot easily be estimated because most of them are used for subsistence of the family. The farmer has usually no cash income from his pond production. There are of course a few exceptions, where advanced fish farmers sell a good part of the catches in neighbouring markets (Lemasson and Bard, 1964).

The largest expenses in the introduction of fish culture in Africa have certainly been incurred by the public sector which established fish culture and fry production centres.

5.2 Large farms

Where larger fish farms have been established for feeding the dependents of larger agricultural farms or missions (Congo, Leopoldville, Mozambique) own labour force and farm equipment is used and payment of labour is often made in kind. The larger Panyam fish farm in Nigeria, for instance, was built by hand 16 years ago, utilizing local labour.

The costs of pond construction per ha of water surface cannot even be estimated. They will certainly vary considerably in different countries and areas.

Pond construction for a brackish-water fish farm in 150 acres of mangrove area in a densely populated region where compensation to landowners had to be paid, where wage-tariffs existed and where the work was done by building contractors, was estimated at £15,700 by Pillay (FAO/UN, 1965). This included compensation, bush clearance, earth movement of 83,000 cu yds (3s per cu yd), two main sluices and 20 subsidiary sluices in concrete and steel construction. These figures are certainly not typical for the whole of Africa and do not apply to home-ponds. They might serve as guide-line for the construction of major farms and fish culture centres.

No norms can be established for recurring expenditure. They will vary considerably by country, area, situation and type of production. The Panyam Fish Farm in Nigeria had to be entirely self sufficient. The farm had to have facilities for building its own boat, maintain its own lorry park, its own workshop etc, whereas the Buguma Fish Farm (FAO/UN, 1965) is situated near a small town and close to the modern harbour-town, Port Harcourt, where some supplies and repair facilities are available. Pillay (FAO/UN, 1965) estimates recurrent expenditures in this case at £1,600 per annum.

The income of economic farms will depend not only on their production but also on their marketing situation: distance, capacity and purchasing power, price structure, availability of roads and water-ways, means of transport, etc.

6 PUBLIC HEALTH ASPECTS

During the explosive development of tilapia culture in Africa, the hygiene services of several countries have expressed concern and even requested a complete ban on pond fish culture e.g. in Uganda, Kenya, Congo (Leopoldville) (Coche, 1960) because they thought it might spread human diseases like malaria, yellow fever and bilharzia (schistosomiasis).

With respect to diseases transmitted by mosquitoes the prevailing opinion of biologists seems to be that in most areas where there are already many small natural waters and swamps the introduction of pond fish culture does not aggravate the situation. All cultured fish feed on mosquito larvae when they have access to them (Coch, 1960; Kiener, 1963). In well maintained and well stocked tilapia ponds, mosquito larvae have not been found; phytophagous tilapia destroy filamentous algae which are the favoured habitat for anophelid larvae; Stegomya larvae occur more in the open water where they can be reached by the non-herbivorous fishes as well. In ponds, where larger fish cannot reach the mosquito larvae (shallow shores, plant thickets, rice paddies) Gambusia affinis is an efficient biological control for mosquito larvae.

Only in very dry areas, where natural habitats of mosquito larvae are rare, fish ponds may eventually promote the spreading of malaria (but rarely yellow fever).

Much more serious is the danger of spreading schistosomiasis (bilharzia). Indeed many newly created ponds contain soon the host snails (Planorbidae and Limnaeidae) of Schistosoma larvae and the disease spreads in the population. Even in scientifically controlled fish breeding centres Schistosoma infestation of epidemic character has occurred (e.g. Yaoundé in Cameroon ; Bard, 1960f; Gamet et al, 1965; Murgo, 1963). Public health authorities have tried to control schistosomiasis by destroying the vector snails with chemicals. Specific malaccocides not affecting aquatic flora, fish and other aquatic fauna have not yet been found. Utilization of malaccocides is therefore prohibited in fishing waters and culture ponds. Experiments in controlling the vector snails with malaccophagous fishes, using the East African Cichlids, Astatoreochromis alluaudii (Congo-Leopoldville, Kenya, Uganda, Cameroon) and Haplochromis mellandi (Congo-Leopoldville) have given the most promising results.

These fishes have less value as food fish and are kept in ponds together with tilapia. The use of malacophagous fishes for schistosoma control is not yet commonly practised.

7 CONCLUSIONS

With the creation of thousands of home-ponds in a period of 10 to 15 years, fish culture can be considered as definitely introduced into the African economy. This is indeed a great achievement.

However, after the first explosive growth of fish culture, in many countries development has almost come to a standstill or has even suffered a conspicuous setback in recent times (Bard, 1962c; Lemasson and Bard, 1964). This calls for a review of the situation and re-orientation of policy.

The reasons for the recent stagnation and apparent recession are manyfold. Among the various methods of tilapia culture only one has been widely adopted i.e. the mixed culture of age classes.

For getting reasonable results, heavy stocking and feeding, regular thinning and restocking after complete draining of the pond as well as good maintenance of the ponds and weed control are necessary. If one of these is neglected, over-population and stunting can result. This is occurring often in African home-ponds and is probably the principal reason for the loss of interest in fish culture in certain areas.

The practice of continuous harvesting of large fish (fast-growers) and keeping the small ones, including the slow-growers, is antiselective and will lead in the long run to hereditarily slow-growing races. Stocks should therefore be continuously "refreshed" with "wild" fish from natural waters.

The whole pattern of the present fish culture would have to be changed with the introduction of other methods.

Rearing in age-groups would make it necessary for farmers to have more than one pond, or they will have to group their ponds into production units on a cooperative basis.

Control of over-population by predators is not an ideal solution because the farmer cannot assess properly the efficiency of the predator before total fishing.

Sexing is not easy for the average African farmer. Also, to use this method more than one pond is required; at least one for propagation and one for rearing the monosex stock. If public hatcheries have to produce monosex stocks for home-ponds, more and larger hatcheries would be needed. They would have to deliver to a pond owner the exact number of fish needed for the optimal utilization of the natural food production and available fertilizer or additional food. To do this, the hatchery personnel should know every pond or get at least full information about their productivity. As many thousand ponds have been built this seems to be impossible.

The explosive development of fish culture has obviously slipped out of the control of the fishery authorities. A large number of poor ponds, with respect to size, water supply, drainage etc, have been created by inexperienced farmers. Direct influence of fish culture centres affect only a smaller number of ponds. Extension services are inadequate with respect to size and often quality. It seems to be impossible to form and maintain the cadres necessary for the permanent supervision of each of the numerous private ponds.

The average African farmer was not educated to carry out fish culture. Only "advanced farmers" have been able to maintain a higher production over a long period (Lemasson and Bard, 1964). The ease of creating a small pond with minimal capital investment and the ease with which tilapia propagate (the "curse" of tilapia culture) have created the attitude that no effort is needed for producing fish in ponds.

The economic infrastructure which has developed in other countries in connection with fish culture (in Asia: professional fry-catchers of fishes, which do not reproduce in ponds, young-fish producers for supplying production ponds, specialized traders; in Europe: young-fish producers for pond owners, who have not the facilities for their own young-fish production, specialized dealers with specialized transport equipment) do not exist in Africa. The existing breeding stations would not be in a position to produce the whole stocking material for all existing fish ponds, much less the stocking material for rice fields if rice-field fish culture is to be introduced on a larger scale.

The lack of a specialized trade in pond fish is a handicap for the development of commercial fish farming. The small and irregular surplus of subsistence ponds does not allow the development of such trade. Similarly a trade in agricultural fertilizers does not yet exist, nor does a trade in animal fodder.

The home-pond fish culture is badly integrated with agriculture. The most important work in fish culture (draining and restocking) has to be done after the dry season, when water for refilling the ponds is available. This is also the time of land cultivation. As fish culture is principally a side-line occupation of the agricultural farmer, the work on the ponds may often be neglected in favour of agricultural work.

Changes in the economic and administrative patterns after political independance have obviously caused in some cases a recession in development (loss of extension cadres).

Future fish culture development policy in Africa should be directed to:

(a) making the fishery services, especially the extension services, more efficient;

(b) making the fish farmer more independant from fish culture and extension service centres: better training, own fry production, grouping of ponds in economic units;

(c) creating the "professional fish farmer" for commercial fish farming in larger pond systems. Commercial fish farming would also have a beneficial effect on home-pond subsistence fish culture;

(d) creating the infrastructure for a large-scale commercial fish culture economy; and

(e) developing and improving culture and management methods in research centres so that they can easily be used in practical fish farming.

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Appendix I

Warm-water pond fish culture in the African Region

	Introduction started	Main fish cultured	No. of ponds constructed	Area covered (ha)	No. of ponds in operation	Fish culture stations	Production in metric tons	Distribution of fingerlings	Remarks
Algeria									No information; probably no fish culture
Angola									No information; probably no fish culture
Basutoland		Trouts				Maseru			For river stocking for sport fishing
Betchuana-land									No fish culture
Burundi	1950	Tilapia	352	65	none	Karuzi			
Cameroon	1952	Tilapia Heterotis	9,000		5,000	Yaoundé Foumban Bertoua Ngaoundéré			
Central African Republic	1952	Tilapia Heterotis	20,000		5,000	Bangui Berberati Bambari Bouar Bria Ouango Bossembele			In 1956 three extension teams with about 40 extension workers; Operations since abandoned
Chad Republic									No fish culture
Congo (Brazza-ville)	1953	Tilapia	12,176	125	3,000	Dioumouna		none	In 1958, 46 extension workers and five expatriates; No operations now.

Appendix I (contd.)

Warm-water pond fish culture in the African Region

Country	Introduction started	Main fish cultured	No of ponds constructed	Area covered (ha)	No of ponds in operation	Fish culture stations	Production in metric tons	Distribution of fingerlings	Remarks
Congo (Leopoldville)	1947	Tilapia	122,067	4,058		Kipopo Yackama Bambesa Kianza Kwili Kwanso Gandajika Dibaya Kubinda Kisampa-Senter Heenen-Keyberg Dilolo Kolwezi Kongolo Kapanga Sandoa Nyakabera Kisamba Paulis Wamba Nyangara Stanleyville Komba Djngu	1,406		Figures of 1960
Dahomey									No fish culture
Ethiopia									No fish culture
Gabon	1956	Tilapia	several "thousand"		1,500	Wolen N'Tem Nyanga N'gounié Libreville Oyem Tschibanga 4 smaller ones			In 1959, 18 extension workers

Appendix I (contd.)

Warm-water pond fish culture in the African Region

Country	Introduction started	Main fish cultured	No. of ponds constructed	Area covered (ha)	No. of ponds in operation	Fish culture stations	Production in metric tons	Distribution of fingerlings	Remarks
Gambia									No fish culture, rice-cum-fish culture planned
Ghana	1953	Tilapia	less than 30			Nungua Bawku Lawra			Stations are mainly for stocking dams
Guinea	1953								No information
Ivory Coast	1956	Tilapia	340		many abandoned	Bouake 9 hatcheries. (10 percent demonstration ponds)			Little private initiative; in 1958, 38 extension workers
Kenya	1957	Tilapia Trouts	12,200	610		Sagana Kiganjo	122 1/ 70 2/	34,900 1/ 70,400 2/	First tilapia trials in irrigation systems 1924
Liberia	1959	Tilapia	"very few"			Gbaruga Suakoko			
Madagascar	1950	Tilapia Carp Blackbass Trout	85,000			4 centres Périné Apamaherane Ambatofotsy Sisaony. 8 experimental stations, about 40 tilapia breeding stations, 1 trout hatchery			Stations badly staffed, only few extension workers from the beginning. Today 1 expatriate, no extension personnel

1/ Tilapia
2/ Trouts

Appendix I (contd.)

Warm-water pond fish culture in the African Region

Country	Introduction started	Main fish cultured	No. of ponds constructed	Area covered (ha)	No. of ponds in operation	Fish culture stations	Production in metric tons	Distribution of fingerlings	Remarks
Malawi									No information
Mali									No fish culture
Mauritania									No fish culture
Mauritius		Tilapia	20	3.2	20		25		
Morocco	1924	Trout [1] Pike [1] Blackbass [1] Carp [2]				Azrou Raz el Ma Arhbal			
Mozambique	1956	Tilapia	About 250 Several larger farms	10.5					
Niger									No fish culture
Nigeria	1951 1954	Tilapia Carp	Few 1 large carp farm	61					Brackish-water fish farm not yet in operation
Rhodesia		Tilapia				Mazoe			For stocking purposes only
Réunion	1940	Trout Tilapia				St. Denis Salazie [3]			
Rwanda	1950	Tilapia	448	84	none	Astuda Kigembe			
Senegal									No fish culture
Sierra Leone									Large-scale tilapia farming planned

1/ For stocking sport fishing waters
2/ In rice fields
3/ Trout and tilapia

Appendix I (contd.)

Warm-water pond fish culture in the African Region

Country	Introduction started	Main fish cultured	No. of ponds constructed	Area covered (ha)	No. of ponds in operation	Fish culture stations	Production in metric tons	Distribution of fingerlings	Remarks
Somalia (Fr.)									No fish culture
Swaziland									No fish culture
Tanzania	1949	Tilapia	8,000						
Togo	1954	Tilapia	514	60	Many abandoned	2 stations 20 hatcheries	Insignificant	300,000	Extension by forestry personnel
Tunisia		Mullets Eels							Brackish-water lagoons
Uganda	1958	Tilapia	11,000	410	6,000	Kajansi Several hatcheries	650 1/ 20 2/	5,340 1/ 29,850 2/	
Upper Volta	1956	Tilapia	About 50		Many abandoned	Bérégadougou			Extension by forestry personnel
Zambia	1961	Tilapia	1,231	100		Solwezi Mwekera Serenje Chilanga Nyanje Kalikali Misamfu	88.5	1960: 414,000 1964: 70,000	

1/ Tilapia
2/ Carps

Appendix II

Fishes used or tried in pond fish culture in Africa

Family	Species	Country	Remarks
Atherinid	Basilichthys bonariensis	Morocco	Experimental
Centrarchidae	Lepomis macrochirus	Congo (Leopoldville)	For blackbass feeding
		Zambia	For blackbass feeding
	Micropterus salmoides	Cameroon	Did not spawn in ponds
		Congo (Leopoldville)	For tilapia control, abandoned
		Kenya	For sport fishing, established in natural waters
		Madagascar	For tilapia control, sometimes spawning difficulties, established in some natural waters
		Mozambique	For tilapia control
		Rhodesia	Together with Lepomis
		Morocco	For sport fishing
		South Africa	For sport fishing
	Pomoxis annularis	Morocco	
	P. nigromaculatus	Morocco	
Centropomidae	Lates niloticus	Cameroon	For tilapia control
		Morocco	For sport fishing
		Nigeria	For tilapia control
		Uganda	var. albertinus, for tilapia control
Characidae	Hepsetus odoë	Cameroon	Experimental
	Hydrocyon vittatus	Mozambique	Experimental
Citharinidae	Citharinus citharus	Congo (Leopoldville)	Does not spawn in ponds
		Nigeria	Does not spawn in ponds
	Citharinus congicus	Congo (Leopoldville)	Does not spawn in ponds
	Citharinus gibbosus	Congo (Leopoldville)	Does not spawn in ponds

Appendix II (contd.)

Fishes used or tried in pond fish culture in Africa

Family	Species	Country	Remarks
Citharinidae	Citharidium ansorgei	Nigeria	Does not spawn in ponds
	Distichodus fasciatus	Congo (Leopoldville)	Does not spawn in ponds
	Distichodus maculatus	Congo (Leopoldville)	Does not spawn in ponds
	Distichodus sp.	Nigeria	Does not spawn in ponds
Cichlidae	Astotoreochromis alluaudi	Cameroon	Mallacophagous, for bilharzia control
		Congo (Leopoldville)	For bilharzia control
		Kenya	For bilharzia control
		Uganda	For bilharzia control
	Hemichromis fasciatus	Cameroon	For tilapia control
		Congo (Leopoldville)	For tilapia control
		Ivory Coast	For tilapia control
		Upper Volta	For tilapia control
	Haplochromis mellandi	Congo (Leopoldville)	For bilharzia control
	Paratilapia pollenii	Madagascar	Experimental
	Serranochromis robustus	Congo (Leopoldville)	For tilapia control
	Serranochromis thumbergi	Congo (Leopoldville)	For tilapia control
	Tilapia aurea	Uganda	Experimental
	Tilapia andersonii	Congo (Leopoldville)	Experimental
		Rhodesia	Perhaps confused with T. macrochir
		Zambia	
	Tilapia christii	Zambia	
	Tilapia esculenta	Tanzania	
	Tilapia flavomarginata	Gabon	
	Tilapia galilea	Cameroon	
		Central African Republic	
		Congo (Brazzaville)	
		Congo (Leopoldville)	
		Ghana	
		Ivory Coast	
		Morocco	
		Togo	

Appendix II (contd.)

Fishes used or tried in pond fish culture in Africa

Family	Species	Country	Remarks
Cichlidae	Tilapia heudeloti	Nigeria Tanzania	Brackish-water culture
	Tilapia leucosticta	Uganda	
	Tilapia macrochir	Cameroon Central African Republic Congo (Brazzaville) Congo (Leopoldville) Gabon Ivory Coast Madagascar Rhodesia Tanzania Togo Upper Volta Zambia	
	Tilapia marginata	Cameroon	Experimental
	Tilapia melanopleura	Cameroon Congo (Brazzaville) Congo (Leopoldville) Gabon Madagascar Mozambique Nigeria Tanzania Togo Uganda Zambia	Confused with Tilapia zillii Brackish water
	Tilapia mossambica	Congo (Brazzaville) Congo (Leopoldville) Madagascar Mozambique Rhodesia South Africa Tanzania Uganda Zambia	

Appendix II (contd.)

Fishes used or tried in pond fish culture in Africa

Family	Species	Country	Remarks
Cichlidae	Tilapia multifasciata	Cameroon Ivory Coast	
	Tilapia nigra	Congo (Leopoldville) Kenya Mozambique Uganda	
	Tilapia nilotica	Cameroon Congo (Brazzaville) Congo (Leopoldville) Central African Republic Gabon Ghana Ivory Coast Madagascar Tanzania Togo Uganda Upper Volta	
	Tilapia sparmanii	South Africa	Cultivated as food fish for black-bass
	Tilapia tholloni	Cameroon	Possibly confused with T. melanopleura
	Tilapia zillii	Cameroon Central African Republic Congo (Brazzaville) Congo (Leopoldville) Gabon Ghana Ivory Coast Madagascar Morocco Tanzania Togo Uganda Upper Volta	Probably often confused with T. melanopleura Differentiates the "races" T.zillii (local) and T. zillii (Congo)

Appendix II (contd.)

Fishes used or tried in pond fish culture in Africa

Family	Species	Country	Remarks
Cichlidae	Tylochromis lateralis	Congo (Leopoldville)	Experimental
Claridae	Clarias sp.	Congo (Leopoldville)	
Clupeidae	Alosa finta	Morocco	Experimental - not successful
Cyprinidae	Barbus aeneus	South Africa	For river stocking
	Barbus caudovittatus	Congo (Leopoldville)	Experimental, does not spawn in ponds
	Barbus occidentalis	Nigeria	Experimental
	Carassius auratus	Madagascar	Settled in natural waters
	Cyprinus carpio	Congo (Leopoldville)	Experimental
		Ghana	Experimental, not successful
		Madagascar	Since 1914, settled in natural waters
		Morocco	In rice paddies
		Nigeria	
		Rhodesia	
		South Africa	
		Uganda	
	Gardinus (Leuciscus) rutilis	Madagascar	
		Morocco	In rice paddies
	Labeo lineatus	Congo (Leopoldville)	Experimental
		Nigeria	Experimental
	Tinca tinca	Madagascar	
		Morocco	In rice fields
Esocidae	Esox lucius	Madagascar	
	Esox masquinongy	Morocco	For sport fishing
	Esox niger		
Gymnarchidae	Gymnarchus niloticus	Cameroon	Experimental
		Nigeria	Experimental

Appendix II (contd.)

Fishes used or tried in pond fish culture in Africa

Family	Species	Country	Remarks
Mugilidae	Mugil cephalus	Tunisia	Brackish water
	Mugil falcipinnis	Nigeria	Experimental, brackish water
	Mugil grandisquamis	Nigeria	Experimental, brackish water
Ophiocephalidae	Ophiocephalus obscurus	Cameroon	For tilapia control, abandoned
		Nigeria	Experimental, for tilapia control
Osphronemidae	Osphronemus goramy	Madagascar	Experimental
Osteoglossidae	Heterotis niloticus	Cameroon Central African Republic Congo (Brazzavile) Congo (Leopoldville) Ivory Coast Madagascar Nigeria Togo	
Percidae	Lucioperca lucioperca	Morocco	For sport fishing
	Perca fluviatilis	Morocco	For sport fishing and rice fields
Polypteridae	Polypterus senegalus	Cameroon	Experimental, abandoned
Poecilidae	Gambusia affinis	Ghana Madagascar (probably also in many other countries)	For malaria control
Salmonidae	Salmo gairdneri	Basutoland	Experimental
		Kenya	For sport fishing
		Madagascar	
		Morocco	For sport fishing
	Hucho hucho	Morocco	Experimental, no success, cold water fish
	Salmo letnica	Morocco	For sport fishing, cold water, high altitudes

Appendix II (contd.)

Fishes used or tried in pond fish culture in Africa

Family	Species	Country	Remarks
Salmonidae	Salvelinus sp.	Morocco	For sport fishing, cold water, high altitudes
	Salmo trutta macrostigma	Morocco	For sport fishing, cold water, high altitudes
Tetrodontidae	Tetrodon fahaca strigosus	Cameroon	Experimental, for tilapia control, poor results

Crustaceae

Penaeidae	Paenaeus duororum	Nigeria	Experimental, brackish water
Astacidae	Procambarus clarkii	Uganda	Experimental
Palaemonidae	Macrobrachium lepidactylus	Kenya	Experimental

APPENDIX III

Tilapia hybridization experiments in Africa

Species crossed (male given first)	Country	Reported by	Remarks SR=sex ratio
Tilapia andersonii x *T. macrochir*	(Katanga) Congo L. (N.Rhod.) Zambia	Bard, 1960, 1962b Mortimer, 1960	SR less than 100 percent monosex No conclusive results
Tilapia andersonii x *T. mossambica*	(N.Rhod.) Zambia	Bard, 1960, 1962b Mortimer, 1960	SR less than 100 percent monosex No conclusive results
Tilapia aurea x *T. nilotica*	Uganda	FAO/UN, 1965	SR less than 100 percent monosex
Tilapia leucosticta x *T. nigra*	Uganda	FAO/UN, 1965	SR less than 100 percent monosex
Tilapia leucosticta x *T. nilotica*	Uganda	FAO/UN, 1965	SR less than 100 percent monosex
Tilapia macrochir x *T. nilotica*	Cameroon Ivory Coast	Bard, 1960, 1962b Bard, 1960, 1962b Bard, 1960, 1962b	SR less than 100 percent monosex Poor hybrids SR less than 100 percent monosex
Tilapia mossambica x *T. macrochir*	Rhodesia	Bard, 1960, 1962b	SR less than 100 percent monosex
Tilapia mossambica x *T. nilotica*	Uganda	FAO/UN, 1965	100 percent males
Tilapia mossambica x *T. thollonii*	Germany	Peters *et al*, 1961	For behaviour research
Tilapia nigra x *T. mossambica*	East Africa	Bard, 1962b	SR less than 100 percent monosex
Tilapia nigra x *T. nilotica*	Uganda	FAO/UN, 1965	SR less than 100 percent monosex
Tilapia nigra x *T. zillii*	East Africa	Bard, 1960, 1962b	SR less than 100 percent monosex
Tilapia nilotica x *T. macrochir*	Cameroon, Ivory Coast, Gabon	Bard, 1960, 1962b	SR less than 100 percent monosex
Tilapia nilotica x *T. mossambica*	Uganda	FAO/UN, 1965	SR less than 100 percent monosex No information
Tilapia nilotica x *T. nigra*	Uganda	FAO/UN, 1965	SR less than 100 percent monosex
Tilapia zillii x *T. menalopleura*	Uganda	FAO/UN, 1965	No interbreeding

APPENDIX IV

Food materials used or recommended in African tilapia culture

1. Aquatic — mainly for herbivorous species:

Most soft submerged and semi-submerged water flora.
The following are mentioned specificially:

Characeae; Chlorophyseae; Conjugatae; Hydrilla; Lagerosiphon; Leesia; Potamogeton; Sparganium.
(Plants which are not taken or only when young, by herbivorous tilapia are carex; Ceratophyllum; Cyperus; Echinochlon; Fimbristylis; Numphaeaceae; Pistia; Scirpus; Typha; Vallisneria.)

2. Terrestrial — for herbivorous and onmivorous species:

All kinds of soft vegetation and household and rural wastes.
Specifically mentioned are:

Banana leaves minced, baobab press cakes, batata leaves, batata tubers cooked, beer wastes dry, bracken, green, bran, brewery waste, brewery malt, cabbage leaves, canna leaves, carrot tops, cocoa leaves, cocoa pulp, colocasia leaves, copra press cakes, cotton seeds ground, cotton-seed press-cakes, garden weeds, green grass, fruits, cooked, soft ones raw, ground-nuts ground, ground-nut press-cakes, ground-nut shells, wastes from chicken farms, kale, kitchen waste, lettuce, maize cooked, maize bran, maize cobs, broken up, maize-crushed, maize leaves, maize flour, mandioca (= cassava) leaves, mandioca meal cooked, mandioca meal dry, mandioca skins, mandioca tubors cooked, milo meal cooked, milo meal dry, "napier fodder", palm-nut press-cakes, papaya leaves, potatoes, pumpkin, rice, rice bran, rice waste, rubber seeds ground, soft shore vegetation, soybeans ground, soybean waste, spinach, termites, wheat waste.

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STATUS OF FISH CULTURE IN THE NORTH AMERICAN REGION

by

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STATUS OF FISH CULTURE IN THE NORTH AMERICAN REGION

Abstract

Fish culture developed after 1850 in the North American region. Public agencies operate complex hatchery systems to produce the fish needed to sustain and improve sport and commercial fishing. Fish farming has become an important industry since World War II, and it will continue to expand. Production efforts are concentrated on channel catfish, Ictalurus punctatus (Rafinesque), salmonids, other sport-fish species, and bait fishes due to consumer, food and recreational habits. Most fish farms are operated by individuals for supplementary incomes. Technical and financial assistance is obtainable from various governmental agencies.

SITUATION DE LA PISCICULTURE EN AMERIQUE DU NORD

Résumé

En Amérique du Nord, le développement de la pisciculture date de 1850. Des complexes d'alevinage relevant d'organismes publics produisent les poissons nécessaires pour alimenter et améliorer tant la pêche sportive que la pêche commerciale. La pisciculture fermière, qui a pris de l'importance depuis la Seconde Guerre mondiale, est en expansion continue. La production porte essentiellement sur le poisson-chat Ictalurus punctatus (Rafinesque), les Salmonidés, d'autres poissons de sport, et les poissons-appâts, pour répondre aux goûts des consommateurs, ainsi qu'aux habitudes alimentaires et sportives. La plupart des exploitations appartiennent à des particuliers, pour qui elles constituent une source de revenu complémentaire. Les éleveurs peuvent obtenir une aide technique et financière en s'adressant à divers organismes d'Etat.

ESTADO DE LA PISCICULTURA EN AMERICA DEL NORTE

Extracto

La cría de peces empezó a practicarse en América del Norte a partir del año 1850. Entidades públicas explotan complejos criaderos para sostener y mejorar la pesca deportiva y comercial. La piscicultura en las granjas se ha transformado en una importante industria después de la segunda guerra mundial, y continuará expandiéndose. Las actividades de producción se concentran en el bagre del canal (Ictalurus punctatus, Rafinesque), en los salmónidos y otras especies aptas para la pesca deportiva, y en los peces para cebo, debido a los gustos del consumidor, los hábitos alimentarios y los fines recreativos. Casi las granjas piscícolas son explotadas por particulares para obtener ingresos suplementarios. Varios organismos estatales ofrecen ayuda técnica y económica.

1 THE REGION

Canada and the United States, including Hawaii, comprise the North American region. The rest of the North American continent, Mexico through Panama and the West Indies, is included in the Latin American region of FAO.

2 DEVELOPMENT OF FISH CULTURE

Fish culture is not indigenous to North America. According to Dr. R.B. Woodbury of the Smithsonian Institution (personal communication) there is no evidence that fish culture was practised in the pre-Columbus era. Immigrants to the New World transplanted wild fish from water to water as they moved inland, but fish culture per se was not developed until the nineteenth century. Experimental production by artificial fecundation is documented for the brook trout, Salvelinus fontinalis (Mitchill), and fallfish, Semotilus corporalis (Mitchill), in 1804, and American shad, Alosa sapidissima (Wilson), in 1848 (Milner, 1874; Clift, 1872). However, Dr. Theodatus Garlick is recognized as the "father" of fish culture in the United States for his successful work with brook trout in 1853 (Milner, 1874; Garlick, 1883). Milner also reports that 20 species, sub-species or races of fish of the families Salmonidae, Clupeidae, Cyprinidae, Catostomidae, Serranidae, and Percidae were being artificially propagated by 1873.

In 1872, Mr. J.A. Poppe successfully transported carp (Cyprinus carpio Linnaeus) to California from Germany and established what was probably the first intensive pond-rearing unit (U.S. Comm.Fish., 1880: 661-6 pp.). The U.S. Commission of Fish and Fisheries also imported carp and related species from Germany in 1876 and later years (U.S. Comm.Fish., 1879 and 1880). The carp was widely dispersed throughout North America before interest in the fish diminished due to lack of its acceptance as a food fish.

Propagation techniques were then developed for escocids, ictalurids and centrarchids, while further advances were made in salmonid culture. Fish cultural efforts, as in the past, were concentrated on improving the yields of sport and commercial gear, rather than utilizing the full potential of impounded waters for fish production. However, since World War II, commercial food and bait fish farming has become an important industry in the United States.

3 REVIEW OF THE HIGHLIGHTS IN FISH CULTURE

3.1 Canada [1]

Commercial fish farming is still quite limited in Canada. The Province of Ontario, probably the best suited area for such enterprises, sold only 57 licenses during 1965 for the operation of private hatcheries. However, many of these units obtained two licenses, one for marketing food fishes and another for marketing live game fishes, so the actual hatchery count was approximately 35.

The rainbow trout (Salmo gairdneri Richardson) accounts for most of the commercial food fish production in Canada where the climate is not suitable for intensive rearing of most warm-water species to edible sizes in ponds. The federal and some provincial governments operate fish hatcheries, primarily to restore or maintain sport and commercial fishing.

1/ Data from personal communications with Mr. E.W. Burridge, Canadian Department of Fisheries and Mr. Chris Armstrong, Ontario Department of Lands and Forests.

Sport fishing is quite important to Canada's economy. Stroud and Massmann (1963) report that 799,456 resident and 593,182 non-resident fishing licenses yielded $4,591,129 in revenue during 1962. The Canadian Department of Fisheries planted 20 million brook trout, Salvelinus fontinalis (Mitchill), and 12 million Atlantic salmon (Salmo salar Linnaeus) during 1965. Coastal provinces have developed extensive Atlantic salmon or Pacific salmon (Oncorhynchus spp.) stocking programs.

Ontario, having 17 units and a new sub-station, maintains the largest inland fish hatchery system in Canada. Their 1965 distribution was about 50 million fish of the following species:

Cisco or lake herring	Coregonus artedii Le Sueur
Lake whitefish	Coregonus clupeaformis (Mitchill)
Landlocked sockeye salmon or kokanee	Oncorhynchus nerka (Walbaum)
Rainbow trout	Salmo gairdneri Richardson
Brook (and aurora) trout	Salvelinus fontinalis (Mitchill)
Lake trout	Salvelinus namaycush (Walbaum)
Splake (hybrid)	brook trout male X lake trout female
Muskellunge	Esox masquinongy Mitchill
Smallmouth bass	Micropterus dolomieui Lacépède
Largemouth bass	Micropterus salmoides (Lacépède)
Walleye	Stizostedion vitreum vitreum (Mitchill)

Much of this production was used in the Great Lakes restoration program following the successful reduction of the sea lamprey (Petromyzon marinus Linnaeus) population through joint efforts of Ontario, the Canadian Department of Fisheries, the Lake States, and the U.S. Fish and Wildlife Service.

3.2 United States [1/]

It is estimated that almost 70,000 acres (28,300 ha) of water are devoted to commercial warm-water food fish culture and another 30,000 acres (12,145 ha) to commercial bait fish production in the United States. Most of this water was activated for fish production after 1945. Recent developments indicate that extensive culture methods for multiple species combinations and fish-rice crop rotation practices are rapidly being replaced by the intensive rearing of a single species, the channel catfish, Ictalurus punctatus (Rafinesque). Approximately 35 million pounds (15,909,000 kg) of impoundment-reared channel catfish were marketed during 1965. Bait fish production for the use of anglers is probably even more important economically since it represents an annual market value approaching $30 million. Considerable expansion of catfish and bait fish production facilities is anticipated due to the success of these ventures and the abundance of suitable development areas. The U.S. Trout Farmers' Association (personal communication) estimates that the annual commercial production of trout is 5.5 million pounds (2.5 million kg) in the United States; of which, 2.5 million pounds (1,136,360 kg) are sold alive, and the balance are dressed. Sites with the necessary volume of cool water for trout culture are quite limited so expansion of the industry will be slower than that for pond fishes.

Fishery Leaflet 46 (Anon.,1966a) lists 1,118 dealers in trout and pond fishes in the United States. This does not include food or bait fish producers unless they also raise and

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1/ Data on commercial pond fish farming from personal communications with Messrs. Kermit Sneed and Mayo Martin, Bureau of Sport Fisheries and Wildlife, Fish Farming Experimental Station, Stuttgart, Arkansas.

sell live game-fish for stocking. Most of these commercial fish hatcheries are relatively small units operated by individuals for supplemental income.

The Soil Conservation Act of 1935 and later legislation initiated the construction of ponds and other upstream flood and soil erosion control units on farms and ranches by offering technical and financial assistance for their development. By 1965, a total of almost 1.5 million water impoundments had been built under the auspices of these programs; more than half of which are also being used for sport, food or bait fish production (Anon., 1966b). King (1960) calculated that private farm ponds stocked by the Bureau of Sport Fisheries and Wildlife provided over 20 million sport fisherman days in 1959. Increasing interest in sport fishing coupled with the population explosion has created a need for many more recreational areas, thereby accelerating fee-fishing or the development of commercialized water sport enterprises.

The production of tropical aquarium fishes in ponds is important in southern Florida. Other areas support some outdoor tropical fish culture during the summer months, but most of the fancier species are propagated indoors. Aquarium fishes have generated a multi-million dollar industry at the retail level in recent years.

The Bureau of Sport Fisheries and Wildlife, practically all of the fish and game agencies of the 50 states, and some county and municipal governments operate fish hatcheries. Production from these sources is stocked primarily in public waters to improve or maintain sport and commercial fishing. The Bureau and many state agencies also furnish fish free of charge for stocking non-commercial waters owned or controlled by individuals. Much of the stocking emphasis is on sport fishing because fishing is the most popular outdoor participating sport in the United States. In 1965, more than 28 million persons or 20 percent of the population of age 12 and over fished in fresh and salt water (U.S.Bur. Sport Fish.Wildl., 1966).

Hagen and O'Connor (1959) list the species of fish produced by public agencies during the reporting year 1957 or 1958. This total production from 482 state and 95 federal hatcheries was 999,633,120 fish weighing 15,195,876 pounds (6,907,216 kg). Appendices I and II are abstractions of data from their work for pond fishes only. Current production data from the states are not available. The Bureau's hatchery system has increased its production by 140 percent between 1957 and 1966 to a total of 4,747,984 lbs (2,153,686 kg). It is assumed that the state agencies have made similar increases.

Culture methods, feeds and feeding for most species of fish produced in North America are adequately covered in papers presented at this Symposium. The following notes in sections 4 and 5 enlarge on these papers or include information on species not previously reported.

4 METHODS OF CULTURE

4.1 Channel catfish, Ictalurus punctatus (Rafinesque)

Frequently it is not objectionable and sometimes it is necessary to spread channel catfish spawning activities over a period of two months or more. Hatcheries having limited hatching and rearing facilities accomplish this by using the "open-pond" spawning method with a brood fish ratio of one male to two females stocked at the rate of 180 fish per acre (445/ha). Spawning receptacles placed in ponds at the rate of 30 per acre (74/ha) are adequate if the containers are checked daily and spawn removed when found during the peak of the spawning season; usually a period of three weeks. This "open-pond" spawning method does not require 100 percent correct sexing of the brood fish as does pen and aquaria spawning, and it reduces care and feeding costs of the adults.

4.2 Bait fishes (Cyprinidae and Catostomidae)

Bait fishes are raised in farm ponds, natural lakes and other still waters devoid of predaceous fish. Data from Dobie, et al. (1956) and personal communication of Mayo

Martin are included in the following remarks about the more important bait fish species reared in North America.

Goldfish (Carassius auratus (Linnaeus)) culture employs the same spawning and rearing methods used for carp (Cyprinus carpio Linnaeus). Annual yields as high as 4,000 lbs per acre (4,489 kg/ha) have been reported. Goldfish are also propagated for the home aquarium market and as forage in the rearing of predaceous game fish.

The golden shiner, Notemigonus crysoleucas (Mitchill), spawns on submerged debris and vegetation. Fry can be left with adults or moved to separate rearing ponds and reared like carp. Production rates of 1,200 pounds and 300,000 saleable bait fish per acre (1,346 kg and 336,699 fish/ha) are on record.

Fathead minnow (Pimpephales promelas Rafinesque) culture differs from that of the golden shiner only slightly. Four-inch (10.2 cm) clay tiles are provided for spawning receptacles. Production rates are also lower than that for golden shiners.

The white sucker, Catostomus commersoni (Lacépède), is the favourite bait fish in northern pike (Esox lucius Linnaeus) fishing areas. The eggs are stripped and hatched in jars. Fry are stocked in lightly fertilized ponds and reared to saleable size without supplementary feeding.

4.3 Hybrids

According to McClane (1965), a Scotsman by the name of Willoughby theorized in 1686 that hybridizing was possible among salmonids. Since then, hybrids have been produced in every important fish family, but few have been worthwhile. In fact, in North America, the splake, male brook trout Salvelinus fontinalis (Mitchill) x female lake trout Salvelinus namaycush (Walbaum), is the only useful hybrid yet developed. A fertile strain of splake, propagated by Canadian workers, is being used to restore the fisheries of Lake Huron (Great Lakes) where they are proving to be more adaptable and productive than their female parent which once dominated the lake.

4.4 Trout and salmon (Salmonidae)

Trout and salmon culture is adequately described by Leitritz (1959), Davis (1953), Phillips, et al. (1963), and others. Ideally, a 100,000 pound (45,454 kg) per year salmonid production unit should have a constant flow of at least 10 cubic feet (0.28 cu m) per second of 45° to 60° F (7.2° to 15.6° C) water. Although these hatcheries are more compact than facilities for warm-water fish production, the precise and voluminous water requirements greatly limit their development. However, experimentation with tidal ponds and floating rearing pens in bays indicates that these areas might also be adaptable for salmonid culture. Trout are reared on an extensive basis in lentic waters, particularly farm ponds, where summer surface temperatures are below 75° F (23.9° C).

5 FEEDS AND FEEDING

Efficient pelleted diets and feeding guides for channel catfish have been reported by Swingle (1959), Hastings (1964), Tiemeier, et al. (1964), Klussmann (1965) and others. The cost ranges from $ 0.06 to $ 0.10 per pound ($ 0.132 to $ 0.22/kg). Appendix III (from U.S.Bur.Sport Fish.Wildl., 1967) suggests daily feeding levels in percent body weight based on water temperatures and size of fish. Feed conversion rates of 1.2 are common for channel catfish. Intensive rearing methods at Bureau hatcheries have produced yields up to the rate of 3,750 pounds per acre (4,209 kg/ha) in five months.

6 FISH TRANSPORTATION

Truck-mounted distribution tanks are generally used for fish transportation. Hauling capacity is governed by volume of water in the tank, design of tank, and auxillary equipment used. Insulated units, having recirculating waters systems (Macklin, 1959) and an oxygen supply (Maloy, 1963), can be used to haul loads in ratios (unit weights of fish to equal unit weights of water) of 1:1.5 for trout and 1:2.4 for channel catfish. McFarland (1960), McFarland and Norris (1958), Nemota (1957) and others report varying degrees of success in increasing hauling ratios by use of sedative drugs and buffer agents. Phillips and Brockway (1954) and Gebhards (1965), however, found that starvation of the fish before shipment and the maintaining of low water temperatures were more effective than the addition of drugs and buffers.

Maxwell and Thoesen (1965) give the details of hauling and planting large quantities of rainbow trout, Salmo gairdneri Richardson and largemouth bass, Micropterus salmoides (Lacépède), fingerlings by airplanes equipped with water tanks. Sealed plastic containers, 2 mil (0.0048 cm) and thicker, packed in insulated outer cartons, partially filled with water and inflated with oxygen, are also used successfully for surface and air transportation of fish.

7 GOVERNMENTAL ACTIVITIES AND CONTROLS

The U.S. Departments of Agriculture and Commerce offer some form of financial assistance to qualified fish farmers; usually low interest rate loans for development. Technical assistance is readily available from most levels of government. Fishery research is being conducted by state, provincial and several federal agencies, colleges, universities, and private organizations. No figures have been gathered on the number of people engaged in extension work and research. Three fish cultural in-service schools are maintained by the Bureau of Sport Fisheries and Wildlife which are open on a space available basis to state and foreign governmental personnel. The bureau and universities, colleges, states, and private organizations have founded 20 cooperative fishery units to develop programs of research and education relating to fish. Fishery training is also offered at many other colleges and universities.

Licensing and regulations for fish farming are under the jurisdiction of the individual states and provinces. Inter-state and international shipments of processed food fish are regulated by the U.S. Department of Agriculture and Canadian Department of Fisheries.

8 CONCLUSIONS

Most of the channel catfish produced in ponds are marketed in the immediate hatchery area. The present demand for this fish is considerably greater than the productive capacities of fish farming facilities and commercial fishing gear. Extensive and profitable expansion is therefore indicated for catfish farming. Bait fishes, having always been in short supply, have an equally bright future. Other species of pond fishes, however, will offer little incentive to fish farmers unless the food habits of North Americans change drastically. Salmonid production is limited only by the availability of suitable water resources. Future development of more efficient water re-use systems and new salt-water culture techniques could very well accelerate salmonid output. Scientific management of the fishery resources in natural and impounded waters has firmly established the need for hatchery fish to maintain and improve sport and commercial fishing. Hatchery production from governmental agencies will have to be increased to meet these precise and growing demands.

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APPENDIX I

Distribution of pond fishes from state and federal hatcheries in the United States during calendar or fiscal year 1957 or 1958 by species 1/

Agency	Number	Weight
Alabama	2,456,467	4,874
Arizona	43,673	3,628
Arkansas	5,545,239	7,896
California	241,991	509
Colorado	2,698,624	6,374
Delaware	120,000	175
Florida	1,440,000	2,075
Georgia	4,400,000	5,550
Hawaii	9,150	12
Idaho	210,143	569
Illinois	2,089,690	25,927
Indiana	1,592,049	1,690
Iowa	142,074,553	138,154
Kansas	2,319,987	15,817
Kentucky	581,000	681
Maryland	32,859	22
Massachusetts	50,510	2,848
Michigan	884,896	31,162
Minnesota	145,828,242	328,978
Missouri	12,904,116	9,615
Montana	1,349,000	24
Nebraska	2,682,416	8,612
New Jersey	24,398	1,018
New York	98,993,092	28,357
North Carolina	1,458,802	2,144
Ohio	58,217,493	6,090
Oklahoma	1,838,663	3,167
Pennsylvania	475,871	124,747
South Carolina	3,327,388	4,941
South Dakota	14,245,900	27,244
Tennessee	5,463,865	2,462
Texas	14,852,999	20,071
Utah	1,788,729	15
Virginia	414,724	112,390
West Virginia	175,175	6,363
Wyoming	2,442,597	35
State sub-total	533,274,301	934,236
Federal	95,624,723	130,737
Total	628,899,024	1,064,973 lbs 484,079 kg

1/ From Hagen and O'Connor (1959)

APPENDIX II

Distribution of pond fishes from state and federal hatcheries in the United States during calendar or fiscal year 1957 or 1958 by species [1]

Common Name [2]	Scientific name [2]	Number	Weight
Bass			
Largemouth	Micropterus salmoides (Lacépède)	33,948,519	125,107
Smallmouth	Micropterus dolomieui Lacépède	1,086,457	61,131
Rock	Ambloplites rupestris (Rafinesques)	202,738	3,597
Warmouth	Chaenobryttus gulosus (Cuvier)	368,879	696
White	Roccus chrysops (Rafinesque)	200	400
Unclassified	Centrarchidae or Roccus spp.	1,251,853	2,369
Buffalo	Ictiobus spp.	5,072	6
Carp	Cyprinus carpio Linnaeus	1,700	5,525
Catfish			
Channel	Ictalurus punctatus (Rafinesque)	4,973,732	51,357
Bullhead	Ictalurus spp.	1,601,632	210,445
Unclassified	Ictaluridae	2,579,086	88,671
Crappie	Pomoxis spp.	1,919,120	116,592
Minnows	Cyprinidae	1,717,935	1,990
Muskellunge	Esox masquinongy (Mitchill)	4,282,417	1,499
Perch, Yellow	Perca flavescens (Mitchill)	102,845	11,095
Pickerel	Esox spp.	2,771	859
Pike, Northern	Esox lucius Linnaeus	35,819,455	73,754
Shad			
Threadfin	Dorosoma petenense (Gunther)	30,760	38
Unclassified	Clupeidae	3,461,070	692
Suckers	Catostomidae	2,829,787	12,840
Sunfish			
Bluegill	Lepomis macrochirus Rafinesque	69,705,288	183,410
Redear	Lepomis microlophus (Gunther)	6,595,325	10,928
Green	Lepomis cyanellus Rafinesque	533,920	668
Unclassified	Centrarchidae	812,573	10,067
Tilapia	Tilapia spp.	2,900	3
Walleye	Stizostedion vitreum vitreum (Mitchill)	455,062,990	91,234
	Total	628,899,024	1,064,973 lbs 484,079 kg

1/ From Hagen and O'Connor (1959)
2/ Spec.Publ.Amer.Fish.Soc., (2) (1960)

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APPENDIX III

Suggested channel catfish feeding guide [1]

Average daily water temp. °F / °C	65° 18.3°	67° 19.4°	69° 20.6°	71° 21.7°	73° 22.8°	75° 23.9°	77° 25.0°	79° 26.1°	81° 27.2°
Estimated length increase per month - inches	0.24	0.48	0.72	0.96	1.20	1.44	1.68	1.92	2.16
cm	0.61	1.22	1.83	2.44	3.05	3.66	4.27	4.88	5.49
Total length in inches and cm average number per pound and kg	Percent of body weight to feed daily [2]								
3 in (100/lb) 7.6 (220/kg)	1.2	2.4	3.6	4.8	6.0	7.2	8.4	9.6	10.8
4 in (50/lb) 10.2 (110/kg)	0.9	1.8	2.7	3.6	4.5	5.4	6.3	7.2	8.1
5 in (31/lb) 12.7 (68.2/kg)	0.7	1.4	2.2	2.9	3.6	4.3	5.0	5.8	6.5
6 in (17/lb) 15.2 (37.4/kg)	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4
7 in (11/lb) 17.8 (24.2/kg)	0.5	1.0	1.5	2.1	2.6	3.1	3.6	4.1	4.6
8 in (9/lb) 20.3 (19.8/kg)	0.5	0.9	1.4	1.8	2.3	2.7	3.2	3.6	4.1
9 in (5.6/lb) 22.9 (12.3/kg)	0.4	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6
10 in (3/lb) 25.4 (6.6/kg)	0.4	0.7	1.1	1.4	1.8	2.2	2.5	2.9	3.2
11 in (2.5/lb) 27.9 (5.5/kg)	0.3	0.7	1.0	1.3	1.6	2.0	2.3	2.6	2.9
12 in (2/lb) 30.5 (4.4/kg)	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7
13 in (1.5/lb) 33.0 (3.3/kg)	0.3	0.6	0.8	1.1	1.4	1.7	1.9	2.2	2.5
14 in (1.2/lb) 35.6 (2.6/kg)	0.3	0.5	0.8	1.0	1.3	1.5	1.8	2.1	2.3

1/ From Resour.Publ.U.S.Bur.Sport Fish.Wildl., (31) (1967)

2/ More efficient food conversion rates can be obtained by dividing the daily ration into two or more feedings.

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CARP CULTURE IN THE REPUBLIC OF IRAQ

by

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Abstract

Fish culture in ponds was started for the first time in Iraq in 1955. The carp, Cyprinus carpio, is the principal species cultivated; but some Barbus species are also reared separately or in combination with carp.

Feeding experiments indicated that carp production increased four to five times by using corn, barley or cotton seed meal. About one ton of any of the mentioned feeds per donum (1 donum = 2,500 sq m) per season produced 350 to 450 kg while that without feeding did not exceed 86 kg per donum.

Commercial fertilizers 13-13-5-1.5, N-P-K trace elements and 8-9-2, N-P-K, increased the productivity from 200 to 250 kg of fish per donum on an average.

Inorganic fertilizers 13-13-5-1.5 or 8-9-2 with barley increased carp production from 6.7 to 7.6 times. Best growth was obtained when stocking density was 600 fish per donum. Fertilization together with the herbicides 2,4-D, 2,4,5-T, and sodium arsenite were effectively used for weeds control.

LA CARPICULTURE DANS LA REPUBLIQUE D'IRAK

Résumé

En Irak, la pisciculture en étang a débuté en 1955. La principale espèce élevée est la carpe, Cyprinus carpio; toutefois, des essais ont également été faits avec l'espèce Barbus, soit en élevage séparé, soit en association avec les carpes.

Des expériences d'alimentation indiquent que la production de carpes a quadruplé, voire même quintuplé, lorsque les poissons sont nourris avec de la farine de blé, d'orge ou de graine de coton. En fournissant une tonne de l'un quelconque de ces aliments par donum (1 donum = 2 500 m^2) et par campagne, on a obtenu une production allant de 350 à 450 kg, alors que sans alimentation extérieure la production ne dépassait pas 86 kg par donum.

L'emploi d'engrais commerciaux (13-13-5-1,5, N-P-K-oligoéléments et 8-9-2, N-P-K) a permis de porter le rendement de 200 à 250 kg de poisson par donum en moyenne.

En employant des engrais inorganiques 13-13-5-1,5 ou 8-9-2, avec une nourriture à base d'orge, on a pu multiplier la production de carpes par des chiffres allant de 6,7 à 7,6. Les meilleurs résultat ont été obtenus avec une densité de peuplement de 600 poissons par donum. En utilisant, en association avec les engrais, des herbicides (2,4-D, 2,4,5-T et arsénite de sodium), on a obtenu de bons résultats dans la lutte contre les plantes adventices.

LA CARPICULTURA EN LA REPUBLICA DEL IRAK

Extracto

La piscicultura en estanques fue iniciada por vez primera en Irak en 1955. La principal especie cultivada es la carpa, Cyprinus carpio, aunque también, se cultivan independientemente, o en combinación con la carpa, algunas especies de Barbus.

Los experimentos referentes a la alimentación indicaron que la producción de carpas aumentó de 4 a 5 veces utilizando harina de maíz, cebada o semilla de algodón. Una tonelada, aproximadamente, de cualquiera de los alimentos mencionados por donum (1 donum = 2.500 m^2) y por temporada dió una producción de 350 a 450 Kg, en tanto que sin alimentación ésta no excedió de 86 Kg por donum.

Los fertilizantes comerciales 13-13-5-1,5, N-P-K oligoelementos y 8-9-2, N-P-K hicieron aumentar la productividad como promedio desde 200 hasta 250 Kg de pescado por donum.

Los fertilizantes inorgánicos 13-13-5-1,5 u 8-9-2 con cebada aumentaron la producción de carpa de 6,7 a 7,6 veces. El mejor crecimiento se obtuvo cuando la densidad de población era de 600 peces por donum. La fertilización junto con los herbicidas 2,4-D, 2,4,5-T y arsenito sódico se utilizaron con eficacia en la lucha contra las plantas adventicias.

1 INTRODUCTION

Iraq, through its over 20,000 square kilometers of inland waters, produces a wide variety of fresh-water fishes, most of which belong to the carp family. Statistical data collected by the fishery specialists show that the production of these waters does not exceed 30,000 metric tons per year, far below the demand for local consumption. However, biological investigations carried out on inland waters showed that there is a high potential for increase of fish production in the future if proper management and adequate protection measures are applied.

Because of the shortage in animal protein production, the Government of Iraq is fostering a program to increase its production. This program aims at encouraging fish culture in ponds to increase the protein in the population's diet and to counterbalance the decrease in catches from natural waters. This decrease in catches is attributed to several factors, foremost amongst which are improper fishing practices, rivers and stream obstructions, soil erosion and silting and intensive fishery.

The object of this paper is to summarize pertinent findings derived from the experiments that have been carried out on carp (Cyprinus carpio) culture in the Republic of Iraq.

2 POND FISH CULTURE

Fish culture in ponds started for the first time in Iraq in 1955 with an experimental fish farm of 32 ponds at the Zafraniyah Experimental Farm, 16 kilometers south of Baghdad. Since then, these ponds have been increased to 55, covering a total area of 15 hectares of water. These ponds are operated by the Division of Hydrobiology and Fisheries of the Ministry of Agriculture. About twice this area of ponds have been built and operated by the Local Administration of the Ministry of Interior.

In the ten years from 1955 to 1965, the Division of Hydrobiology and Fisheries provided technical assistance to farmers' cooperatives, individual farmers, and land owners for the construction of over 100 ponds, that covered a total area of 30 hectares.

The carp, Cyprinus carpio, is the principal species cultivated in ponds throughout the country. However, the following Barbus species are being tested to evaluate their suitability for pond culture: Barbus grypus, B. xanthopterus, B. luteus, B. sharpeyi.

Each of these species was first tested in a separate pond to study its biology and behaviour and to find out whether it will reproduce in ponds under ordinary pond conditions. After two years it was found that these species failed to spawn in ponds. Because of the high commercial value of these species they were kept separately and in combination with carp in independent ponds for the purpose of evaluating their production in fertilized waters and with supplemental feeding.

These experiments will be conducted for several years before selecting the species that are best adapted to pond fish culture.

A preliminary experiment on the artificial propagation of these species was also conducted in the spring of 1965, without reaching a positive conclusion. It is therefore necessary to resume this work in the future.

As no definite results have as yet been obtained on the suitability of any of these four Barbus species for pond culture, the present paper will deal with the cultivation of common carp only.

2.1 Common carp culture

Two strains of scaled common carp were introduced from Indonesia (punten carp) and Holland (Japanese multi-colour carp) and transferred immediately into ponds. The fry were left in ponds for one year without supplemental feeding and with occasional fertilization. During the second year of life inorganic fertilizers and supplemental feeds were applied as needed to induce rapid growth (Al-Hamed, 1960).

In the spring of the second year fish spawned in ponds and the fry were left in the same ponds until they reached fingerling size before being stocked in other ponds for experimental purposes.

The experiments on carp at the Zafraniyah Fish Culture Station started in the summer of 1959. Investigations were carried out on supplemental feeding, fertilization, rate of stocking, weed control, mixed culture with the Barbus species and other interrelated subjects. The findings of these preliminary experiments are recorded here.

3 SUPPLEMENTAL FEEDING

Preliminary experiments on the effect of various types of supplemental feeds on carp production in ponds have been conducted in ponds of 1/4 donum size, i.e. 625m^2 (1 donum = 2,500 m^2 = approximately 0.6 acre). The results indicated that corn, barley and cotton seed meal increased carp production from four to five times as compared with ponds receiving no supplemental feeds (Al-Hamed, 1961). These results are tentative pending further experimentation on the suitability of various other types of feeds, and the level of feeding under different climatic conditions. However, the production of carp receiving approximately one ton of any of the above mentioned feeds during the experiment period (one vegetative period) ranged from 350 to 450 kilograms per donum, while the production in those ponds receiving no supplemental feeds did not exceed 86 kilograms per donum (Al-Hamed, 1961). These figures indicate that carp production in ponds can be greatly increased provided the proper types and amounts of supplemental feeds are given.

4 FERTILIZATION

As fish culture in ponds is a recently established industry in this country, the problems of pond fertilization which arise from differences of water quality, bottom soils and other factors require further research. The complexity of the problems was reflected in the wide variation of fish production among several unfertilized ponds in one area and in different areas having similar climatic conditions. Moreover, it was observed that unfertilized ponds in some instances gave higher production than fertilized ones. Therefore, it has to be stated that the preliminary results so far arrived at are insufficient to draw specific conclusions. However, the results of preliminary experiments obtained at Zafraniyah Fish Culture Station indicated that commercial fertilizers, 13-13-5-1.5, N-P-K trace elements and 8-9-2, N-P-K, increased the productivity from 200 to 250 kilograms of fish per donum (i.e. from 800 to 1,000 kg/ha). Further experiments on the fertilizer requirements with water of different qualities are currently in progress.

5 EXPERIMENTS ON INORGANIC FERTILIZATION AND SUPPLEMENTAL FEEDING

The first experiment with inorganic fertilizers and supplemental feeds was conducted in the summer of 1960. The results indicated that the use of superphosphate together with barley or cotton seed meal had a more pronounced effect on the growth and production of carp than either one used separately (Al-Hamed, 1961). With this in mind, a combined experiment with modified levels of fertilizer applications with barley was

conducted in summer 1965. Five ponds of 1/4 donum (625 m^2) in size were stocked with a definite number and weight of fish in April 1965 and were given the following treatments:

Superphosphate and cotton seed meal
Superphosphate and barley
8-9-2, N-P-K and barley
13-13-5-1.5, N-P-K trace elements and barley
Control (without treatment)

At the end of September 1965 the ponds were drained and the fish were counted and weighed. The results are given in the following table.

Table I

The effect of fertilization and supplemental feeding on carp production in ponds

Pond No.	Treatment	Yield/kg/donum	kg/ha
1	Sup. and cotton seed meal	321	1,284
2	Sup. and barley	352	1,408
3	8-9-2 and barley	646	2,584
4	13-13-5-1.5 and barley	720	2,880
5	Control	96	384

As shown in Table I, the use of commercial fertilizers, 8-9-2 and 13-13-5-1.5 with barley, increased carp production to almost twice that obtained from superphosphate and barley or cotton seed meal, and 6.7 to 7.6 times that of the control. It may be concluded that the use of fertilizers together with supplemental feeds leads to much higher production than either one alone. Therefore, more emphasis is given to this type of research in order to establish the best combinations of both fertilizers and feeds which give higher economical production.

6 RATE OF STOCKING

Preliminary experiments on stocking densities were carried out in ponds of 1/4 donum (625 m^2) size. Four ponds were stocked in March 1964 with 150, 200, 250 and 300 fish of an average weight of 130 grams. At the end of October of the same year, ponds were drained and the fish counted and weighed. The results are given in the following table.

Table II

The effect of stocking densities on the growth of carp in ponds

Pond No.	No. fish per pond	No. fish per donum	Av. wt. fish (g)	Total weight produced (kg)	(kg/donum)	(kg/ha)
1	150	600	900	135	540	2,160
2	200	800	740	148	592	2,368
3	250	1,000	600	150	600	2,400
4	300	1,200	490	147	588	2,350

As shown in Table II, the stocking rate of 1,000 fish per donum (4,000 per ha) gave the highest production (600 kilograms per donum, 2,400 kg/ha) and that of 600 fish per donum (2,400 per ha) gave the lowest. As a fish of 900 grams is more profitable and desirable to the consumers than that of 600 grams the former figure (600 fish per donum, 2,400 per ha) is the recommendation given to pond owners at the present time.

7 CONTROL OF AQUATIC VEGETATION

Aquatic vegetation is not a serious problem in carp ponds when constructed and managed according to the latest techniques. Otherwise, it poses a problem especially when the ponds are shallow and not adequately fertilized. Reeds (Phragmites) and cattails (Typha) are the dominant obnoxious emergent plants in such ponds. When they are once established in a pond they grow very rapidly so that complete eradication is impossible in spite of continued fertilization and control measures with plant growth-regulators such as 2,4-D and 2,4,5-T. However, in an experiment at the Zafraniyah Fish Culture Station, 2,4-D ester, with tributylphosphate as a co-solvent and kerosene as carrier, has been found to be effective in eradicating cattails when used in 0.5 to 1.0 percent solution. Two sprays of this solution, the first in April and the second in August, proved to be of great value in eliminating these weeds.

To control Phragmites 2,4-D tributylphosphate-kerosene solution was effective, but spraying with 1.0 percent 2,4,5-T solution was more effective in eradicating them.

Submerged aquatic plants are less important than emergents, but sometimes pose a problem when the pond is underpopulated and not properly fertilized. Proper fertilization and adequate stocking rate proved to be effective in controlling such plants. However, sodium arsenite in a concentration of 3 to 4 ppm was found to be very effective in controlling hornwort (Ceratophyllum), water milfoil (Myriophyllum), pond weed (Potamogeton)and naiad (Naias).

These results, obtained from preliminary experiments, are not sufficient to make recommendations on the more effective methods of weed control until further experiments on different methods and materials are conducted.

8 PROBLEMS OF CARP POND MANAGEMENT

The results of a survey of existing carp ponds throughout the country indicated that many ponds fail to produce a satisfactory yield. The principal causes of failure have been investigated and are as follows:

(i) Stocking rate

It is a common occurrence to find a pond of an area less than one donum (0.25 ha) stocked with more than three thousand fish. The owners of such ponds complain that fishes do not grow well. For solving such a problem, demonstration ponds were built in certain districts to demonstrate to the pond owners the effect of stocking rate on the growth of carp in both fertilized and unfertilized ponds.

(ii) Undesirable wild fish

One of the common causes of failure in carp culture is the existence of a great number of wild fish species entering the ponds with the water supply. Results of preliminary experiments revealed that 3 to 3.5 ppm of Malathien 50 percent was effective in

eliminating all the wild fishes without any harmful effect on carp (Al-Hamed, 1965a, unpublished). This material, together with the use of a screening system on the water supply inlet pipes, was recommended to pond owners.

(iii) Pond construction

Proper construction of ponds has a pronounced influence on their successful management. This means that certain requirements and features should necessarily be fulfilled before selecting the pond site and before pond construction (Lawrence, 1949; Al-Hamed, 1965b and others). Many ponds have been constructed without paying any attention to such requirements. Therefore, they failed to be economically profitable. Assistance in selecting pond sites and planning the layout of the ponds was given by the technical staff of the Division of Hydrobiology and Fisheries. As a result of this assistance, the majority of ponds constructed in recent years meet the necessary requirements.

(iv) Pond fertilization

Farmers know that profitable farming requires proper fertilization, but they do not understand and believe that ponds must also be fertilized for higher fish production. Therefore, the majority of the existing ponds are unfertilized and subsequently, they fail to produce profitable yields.

(v) Muddy water

During the spawning period, the flood water which is heavily loaded with silt poses a serious problem for successful spawning. The deposition of silt on eggs affects hatching of a great proportion of the eggs. Investigations carried out in this respect revealed that the construction of desilting tank or pond is necessary for those fish farms that follow a complete system of fish culture.

9 CARP CULTIVATION IN LAKES AND RESERVOIRS

Natural lakes and irrigation and flood water relief reservoirs have recently been utilized for carp cultivation. Two lakes, Hammar and Saniyah, and two reservoirs, Habbaniyah and Tharthar, were stocked with carp fingerlings for the first time in 1960. Since then the fisheries authority have continued to release carp fingerlings in lakes and reservoirs for increasing their fish productivity.

Two years after the first stocking, fishes were caught for growth study. During this period measures were taken to prohibit fishing, so that the carp could grow and reproduce naturally. Preliminary results indicate that carp released in lakes grew faster (1 to 1.5 kg in two years) than those released in reservoirs (700 to 1,000 g). Further investigations on the growth rate, environmental suitability and reproductive potential of carp in natural waters are in progress.

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A RATIONAL APPROACH TO FISH CULTURE IN RURAL AREAS OF ZAMBIA

by

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Abstract

The main features of the three types of fish culture operations that have developed in the rural areas of Zambia are briefly described. Comparative data are presented to show the greater value of conservation dams compared with family ponds, in terms of benefit in cash and protein food to rural peoples and in making the best use of available financial and skilled manpower resources. The construction of artificial lakes is advocated in preference to small family ponds even in regions of high rainfall where there is less immediate need for conservation works.

I/E-2

ESSAI DE PISCICULTURE RATIONELLE DANS LES ZONES RURALES DE LA ZAMBIE

Résumé

Cette communication contient une brève description des principales caractéristiques des trois systèmes de pisciculture qui ont été expérimentés dans les régions rurales de Zambie. Selon des données comparatives, les barrages de retenue sont supérieurs aux étangs familiaux, car ils fournissent à la population rurale un meilleur rapport en espèces et d'avantage d'aliments protéiques, tout en permettant de tirer le meilleur parti possible des ressources disponibles en capitaux et en main-d'oeuvre qualifiée. L'auteur préconise l'aménagement de lacs artificiels plutôt que de petits étangs familiaux, même dans les régions où, en raison des précipitations abondantes, la construction d'ouvrages de conservation des eaux est moins nécessaire.

ENFOQUE RACIONAL DE LA PISCICULTURA EN LAS ZONAS DE ZAMBIA

Extracto

Se describen brevemente las características principales de los tres sistemas de piscicultura practicados en las zonas rurales de Zambia. Se presentan datos comparativos para mostrar el mayor valor de las presas de conservación comparadas con los estanques familiares, tanto en beneficios en metálico como en los alimentos proteínicos que aportan a las poblaciones rurales y el mejor aprovechamiento de los recursos financieros y de mano de obra capacitada disponibles. Se propugna la construcción de lagos artificiales con preferencia a los pequeños estanques familiares incluso en regiones de elevadas precipitaciones donde es menor la necesidad inmediata de obras de conservación.

1 INTRODUCTION

For over 20 years, fish ponds have been advocated in many parts of Africa as one means of providing animal protein to peoples in regions where there is a protein deficiency. Zambia, formerly Northern Rhodesia, was one of the first countries of Africa south of the Sahara, to investigate and to develop the production of fish from ponds and other artificial waters. Because Zambia has large natural fisheries from which the annual fish catch is currently of the order of 41,000 metric tons, the development of fish culture, necessarily has been limited in extent and localized in areas.

As a result of fish culture investigations and practical experiences over some 20 years, it has become apparent in Zambia that the general and widespread development of fish ponds is not necessarily the best, simplest and most advantageous way to utilize financial and manpower resources available to improve the protein diet of peoples in those regions where it is most needed.

Three systems of fish culture that have developed in Zambia are described here briefly and are compared in terms of benefit to rural populations and use of financial and manpower resources.

2 GENERAL FEATURES OF ZAMBIA

In order to appreciate fully the pattern of fish culture development in Zambia, it is necessary to mention briefly certain of the general features of the country.

Zambia is a landlocked country of southern Central Africa lying between latitudes 8 and 18 degrees South and between longitudes 22 degrees and 34 degrees East. About 752,000 square kilometres (290,586 square miles) in area, the country is largely plateau, at an altitude between about 1,100 and 1,400 metres (3,500 to 4,500 feet). The climate is a three-season type; hot and wet; cold and dry; hot and dry. Ambient plateau temperatures are generally within the range of 20°C to 35°C with somewhat higher temperatures in the main valleys and somewhat lower on the limited areas of higher ground.

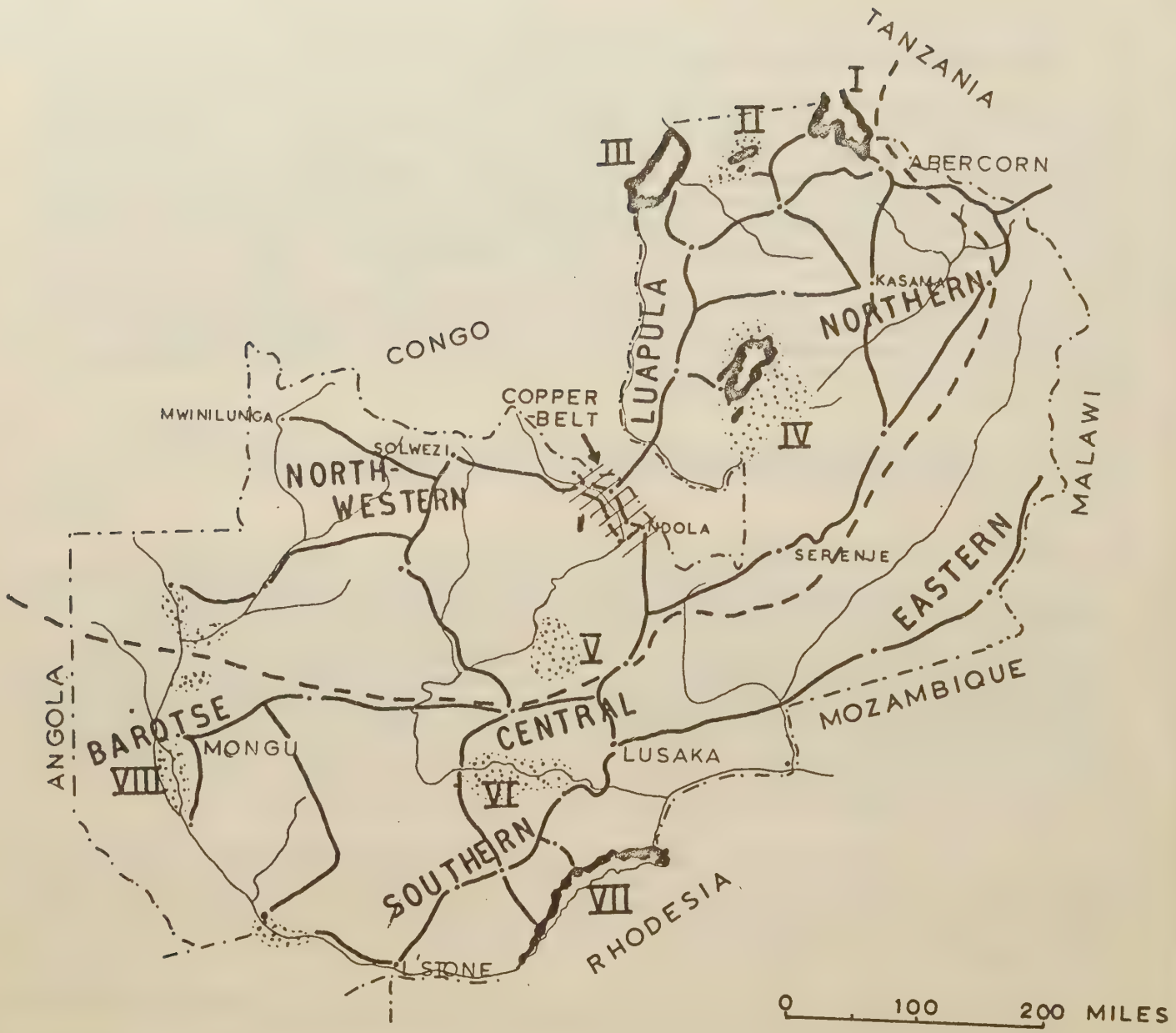
The northern, north western and western regions of the country have a generally higher rainfall of over 1,000 mm (40 inches) and better surface water supplies than the southern and eastern regions (below 1,000 mm). The areas of highest agricultural potential are, generally speaking, in the low rainfall regions and are limited in those of high rainfall.

Despite the adequacy of surface water supplies in high rainfall regions, the rivers and streams of the plateau have limited exploitable fish populations.

Large natural fisheries in the form of lakes, swamps, large rivers and flood plains are located in the northern regions and in the south and west as indicated in Fig. 1. Production from these is distributed either to the industrial towns of the line-of-rail, or within the immediate vicinity of the fisheries. The greatest need for improving the protein diet of the peoples of Zambia is in the high rainfall areas of low agricultural potential, in particular the north-western and parts of the northern regions.

3 FISH CULTURE PRACTICES

Three basic forms of fish culture have developed in Zambia. These are culture in family ponds, in irrigated small holdings, and in conservation dams (small artificial lakes.



MAJOR NATURAL FISHERIES

I	L.TANGANYIKA	V	LUKANGA
II	MWERU WA NTIPA	VI	KAFUE
III	L.MWERU	VII	L.KARIBA
IV	BANGWEULU	VIII	UPPER ZAMBEZI

DIVISION BETWEEN HIGH & LOW RAINFALL REGIONS

FIG. 1 THE REPUBLIC OF ZAMBIA

3.1 Family ponds

In areas of the high rainfall regions, family ponds have developed with the following features.

Ponds are small in surface area, generally about 20 ares (0.2 ha or 0.5 acre). In recent years ponds less than this size are not stocked. Ponds are generally badly constructed, the walls being uneven and weakest where they should be strongest; often ponds are just pits dug in the ground. They seldom have proper drain pipes, screened inflows and overflows or any protection against predators. Ponds are often badly sited, since owners do not always avail themselves of technical advice, and ponds may not have even a perennial water supply.

As a consequence of a low population density in the country, ponds are widely scattered and all too often located some distance from habitation; seldom does an owner have more than a couple of very small ponds, and more commonly only one.

Pond owners have their ponds stocked free of charge from Government Stations, with Tilapia melanopleura and Tilapia macrochir and sometimes, T. andersonii or T. mossambica at the rate of 224 to 336 kg per ha (200 to 300 lb per acre).

Once stocked, ponds seldom receive adequate attention from their owners, who mostly assume that the fish will grow and breed without any effort on their part, in feeding, water control and general maintenance.

Most family ponds are located in the regions of high rainfall and where surface water supplies are best, and have been discouraged in low rainfall areas where surface water supplies are generally poor. However, the quality of the waters of high rainfall plateau regions is generally poor, of low alkalinity and with few salts in solution. As a consequence, the natural production from fish ponds is low, being of the order of 224 kg per ha per annum (200 lb per acre per annum), but can be improved by the use of supplementary feeds and fertilizers, to the order of 897 to 1,121 kg per ha per annum (800 to 1,000 lb per acre per annum). The availability of supplementary feeds is poor due to the low agricultural potential and lack of farm wastes. Feeds are generally limited to cassava and cassava wastes, grass and other green vegetation.

Because of the small size of ponds, the actual annual production available to the owner with say two ponds totalling four ares (0.1 acre) in area is only 9 kg (20 lb) without, and 36 to 45 kg (80 to 100 lb) with supplementary feeding.

Little difficulty has been experienced in the rural areas of Zambia in getting people to build fish ponds. Rural peoples are only too keen to build the ponds, usually after having heard about or having seen a publicity or instructional film or paying a visit to a demonstration unit. The greatest difficulties have been in providing the necessary practical assistance to pond owners, since it has been found that frequent and regular visits are absolutely essential if pond owners are to obtain good production.

3.2 Irrigated small holdings

Irrigated small holdings are a feature of the peri-urban areas of the Copper Belt and some other towns of Zambia. The holdings produce vegetables and may include livestock such as poultry. The addition of fish ponds to irrigated small holdings has been shown to be a practical proposition (Mortimer, Ruth and Muluwa, 1963; Ruth, 1965). A demonstration-teaching unit with facilities for raising ducks, 16 ares (0.4 acre) for growing vegetables and 16 ares (0.4 acre) of fish ponds, has provided over four years a total net profit of £91 per annum of which 24 percent was contributed by the fish

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Table I

The distribution of fish ponds in Zambia, 1965

	Number	Approximate total surface area	
		Ha	Acres
North Western Province *			
Mwinilunga	500	12.1	30
Solwezi	200	4.9	12
Other areas	70	1.6	4
Western Province			
Copper Belt	203	7.3	18
Northern Province			
Kasama	136	5.7	14
Abercorn	46	1.2	3
Other areas	30	0.4	1
Central Province			
Serenje	156	6.5	16
TOTAL	1,341	39.7	98

* The number of fish ponds in the North Western Province is not known accurately

Table II

The distribution of small conservation dams and weirs (artificial lakes) in Zambia, 1965

	Number	Total surface area	
		ha	acres
Southern Province	512	1,647	4,070
Central Province	240	1,072	2,649
Western Province	44	3,314	8,190
Eastern Province	170	6,641	1,641
TOTAL	966	12,674	16,550

Note: Artificial lakes with a surface area of more than 200 ha (500 acres) are not included. The total area of these lakes is about 12,100 ha (30,000 acres)

ponds. One of the main areas where small holdings have developed is the Ndola Rural District close to the Copper Belt, where fish ponds have been a fairly successful addition. The number of holdings with ponds in this area are included in Table I.

Small holding ponds are generally better constructed and managed than family type ponds. This is very largely due to the units being less scattered and more accessible, thus making frequent and regular visits by limited extension staff practicable. In addition agricultural extension staff advising on agricultural matters are able to assist to some extent with fish culture work.

The production of fish from ponds in small holdings is potentially higher than in family ponds due to the availability of agricultural wastes for supplementary feeding and the better attention that can be given to management by the owner, who, of necessity attends to his adjacent garden on most days and so does not have to make special visits to his ponds. Crops from ponds are of the order of 1,100 to 1,700 kg per ha per annum. (1,000 lb to 1,500 lb per acre per annum).

Another feature of small holding ponds compared with family ponds is their larger size and number, which gives a greater actual supply of fish to the owner. The aim in development is to have units of six or twelve ponds of about four ares (0.1 acre) surface area, which would give the owner a fair monthly return in fish or cash. Ponds larger than about four ares in area are not favoured by most owners, as they take too long to construct; an owner is better able to build a number of small ponds than one or two large ones, furthermore, it has been found that small ponds of about four ares tend to produce a relatively greater fish crop than larger ponds of say 20 ares (0.5 acre) surface area.

Because of the commercial aspect, the extent of development of small-holdings that include ponds in rural areas is necessarily limited to the availability of an accessible cash market; a very large number of holdings would be necessary in a rural area to justify transporting produce long distances to urban markets.

3.3 Conservation dams

Mortimer (1964) reported on the conservation dam fisheries of Zambia from 1951 to 1961 and drew attention (1965) to the value of impoundments in improving fish production from streams.

The main feature of conservation dams, or artificial lakes as they could be more correctly described, is that once constructed and stocked with fish, crops can be taken every year. At subsistence level, fish are caught with rod and line, thus fish can be obtained by all levels of the population, and with only little assistance of extension workers. With little additional extension assistance, annual cash crops can be obtained from small dams by fishing with nets.

As Mortimer (1964) recorded, the magnitude of the annual crop from conservation dams in Zambia is related to the size of the dam; in general small dams give a larger crop per unit area than do large dams. From dams of about four ha (10 acres) production is of the order of 112 kg per ha per annum (100 lb per acre per annum) whereas from dams of 20 to 40 ha (50 to 100 acres) surface area the production is only of the order of 34 kg per ha per annum (30 lb per acre per annum). Potential crops from dams are estimated to be three to four times those actually obtained at present.

Another important feature of conservation dams is that even in areas of poor water fertility, annual crops of at least 112 kg per ha (100 lb per acre) have been obtained from dams of up to 16 ha (40 acres) in surface area.

In 1965 there were nearly 1,000 small water conservation works in Zambia (Table II) mostly with a surface area of 2 to 12 ha (5 to 30 acres) with a total surface area of about 670 ha (16,500 acres) and which produced about 800 tons of fish, mainly at subsistence level. This crop represents nearly 1 kg (actually 2 lb) of fish a week for 16,000 people.

In many ways it is unfortunate that the majority of conservation dams are constructed primarily for agricultural and other purposes and not for fish production and are located mainly in those areas of greatest farming potential, where the need for additional protein is least.

The advisability of constructing artificial lakes on their merits for fish production is not yet generally accepted in Zambia, possibly because the high capital outlay required must be justified by something more spectacular than fish, such as hydroelectric works, irrigation projects, domestic water supplies or cattle raising.

4 COMPARATIVE COSTS OF THE FISH CULTURE SYSTEMS

Zambia, like other developing countries in Africa, at this time has problems in obtaining skilled manpower, has large and varied demands on cash resources and a need to improve the standard of living of people in rural areas. This being so, it is not without significance to try and compare the costs of development of different fish culture methods, their skilled manpower requirements and the long and short term benefits in terms of fish production.

Development costs are always difficult to assess because of the many hidden items such as administration expenses and central services. In making comparisons, only those costs that can be defined clearly are itemized and an allowance is made for undefinable costs.

Field staff requirements in fish culture development and extension work in Zambia are at four levels. At the lowest level are daily paid workers who operate demonstration-stock units. At the next level are junior extension staff who are Civil Service employees with a standard of education between Standard VI (pre high school) and Form II (mid high school). Senior extension staff, Technical Assistants and Technical Officers are also Civil Service employees and normally must have had a high school education followed by technical training. A number of Technical Assistants in charge of areas would be under the supervision of a Technical Officer.

Ideally the development of family ponds in an area is preceded by the construction of a pond unit to demonstrate precisely the type of pond layout, construction and management suitable to the area and to provide stock fish for private owners; at the same time junior staff are recruited and trained for extension work in the ratio of one extension worker to 20 expected pond owners. This ideal order of development is seldom attained in Zambia, the provision of a demonstration-stock pond unit and extension staff having to be justified by a number of private ponds already in existence in an area.

Ponds are added to irrigated small holdings after their establishment and seldom is the unit planned as a whole. Since small holdings tend to be grouped in relatively small areas and agricultural extension staff are available for advisory work that can include fish culture, the number of fisheries extension staff required is somewhat less than is required for family ponds, being of the order of one to 25 owners. Although a demonstration-teaching small holding is desirable, in practice only one is required for several development areas, which is a saving in expenditure and trained manpower.

The successful utilization of conservation dams for fish production require comparatively little in the way of extension work. A centrally located demonstration dam, as typical as possible of others in a region, is used for demonstrations and as a source of stock and from which a mobile extension team can operate. A mobile team consisting of a Technical Assistant and five junior staff can effectively service a region with 200 to 300 dams.

In Table III a comparison is made of the costs of fish culture development and extension work from which it can be seen that per unit weight of fish produced, conservation dams show a far better return for cash expended than either small holdings or family ponds, the ratio being about 1:6:20.

To produce the same benefit in terms of fish as 240 conservation dams impounding about 1,100 ha (2,700 acres) at an annual expense of £8,200 and utilizing one senior and five junior extension staff, 1,350 units of family ponds would be needed, even allowing for an increase from 4 to 10 ares (0.1 to 0.25 acres) of ponds per family, and would cost annually about £58,000 for extension services and would require six senior and 60 junior staff. The latter staff requirements represent 50 percent and nearly 30 percent respectively of the 1965 establishment of staff available for all fisheries development and extension work in Zambia.

Allowing the cost of a conservation dam of about 4.5 ha (11 acres) in area at about £2,000, 240 dams represent a capital outlay of about £480,000 which in turn represents in 1965 20,000 man-months of employment (half the capital cost being expended in labour). Over 20 years this capital investment is at the rate of £24,000 per annum. Thus it can be said that 240 conservation dams in capital construction and recurrent extension costs represent £32,200 per annum and show a return of at least 122,500 kg (270,000 lb) of fish a year. To produce this same amount of fish from family ponds requires an annual expenditure of £58,000 in extension services alone without the added advantage of providing paid employment since pond owners are not subsidized for construction work. To pay the construction and ancillary costs of ponds as well would require at least another £50,000 annually.

In addition to the advantages of lower costs and manpower requirements for development and extension work there are other advantages of artificial lakes over family ponds in rural areas of Zambia. For example in areas of poor agricultural potential, where shifting cultivation is practised, there have been a number of instances of people building ponds only to abandon them after a couple of years. Artificial lakes, however, allow for a shifting population, since it is necessary only that a villager go to a dam and catch fish; there is no management required on his part. Management requirements of conservation dams are few; annual inspection and maintenance can be either a central or local government concern - a service provided to the public.

Another feature of dams that has been mentioned already is that they can be fished at subsistence level by all levels of the population; thus even young children can and do catch fish for themselves. The tendency amongst some pond owners to treat the fish in their ponds as wealth and not to crop them is not experienced with dam fisheries, since the fish in them are not owned by any one person.

The recurrent criticism that conservation dams are reservoirs for bilharzia and malaria vectors is for small dams largely invalid. In a dam that is properly constructed and stocked with fish of suitable species bilharzia and malaria vectors are not a serious problem.

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Table III

The comparative cost of fish culture development and extension work

		Family ponds	Small holdings	Conservation dams
CAPITAL COSTS £				
Demonstration-stock unit		1,500	1,500	5,500
Staff housing		18,500	5,400	10,500
TOTAL £		20,500	6,900	16,000
ANNUAL COSTS £				
Salaries and allowances				
Technical Assistant		600	600	600
Unit staff		600	600	600
Extension staff		3,000	600	1,500
Sub-total £		4,200	1,800	2,700
Other costs				
Unit running costs		300	300	300
Vehicles		2,000	1,000	2,000
Fish stocking		500	500	1,000
Capital depreciation (20 years)		1,000	350	800
Central services (20 percent)		1,600	750	1,400
Sub-total £		5,400	2,900	5,500
TOTAL ANNUAL COSTS £		9,600	4,700	8,200
Pond owners	No	200	50	240
Dam areas	Acres	20	25	2,700
	Ha	8.1	10.5	1,092
Average annual production	lb per acre	800	1,000	100
	kg per ha	896.6	1,121	112
Annual total production	lb	16,000	25,000	270,000
	kg	7,258	11,340	122,472
Annual expenditure per unit weight of fish produced (shillings)	per kg	26.4	8.4	1.32
	per lb	12	3.8	0.6

5 SUMMARY

The need to provide additional protein in the diets of rural peoples in Zambia, generally speaking, is greatest in plateau regions of high rainfall and low agricultural potential and poor water fertility. The small family ponds that have developed in these regions have low yields of fish and require a relatively large expenditure for extension and advisory work.

Mixed irrigated small holdings are located mainly in peri-urban areas of Zambia, but where fish ponds can contribute substantially to the cash income of the unit.

Small conservation dams (artificial lakes) are a feature of low rainfall regions, where their primary function is water storage for domestic, industrial or agricultural purposes, yet produce substantial quantities of fish.

In terms of benefit in cash and food to rural communities making the best use of available skilled manpower and financial resources, conservation dams show a better return than do small family ponds; for expenditure in extension and advisory work, the return from conservation dams is about 20 times the return from family ponds.

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POND FISH CULTURE DEVELOPMENT IN GHANA

by

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Abstract

Ghana has had an experimental fish farming program for 12 years. During this period much has been learned and the information obtained could now be used in a program of commercial fish production. Earlier attempts at commercial fish culture were not successful due to lack of trained personnel and difficulties in obtaining field equipment. Experiments indicated that the fishes which can be cultured successfully in Ghana are of the genera Tilapia, Labeo, Lates, Synodontis and Bagrus. Due to prolific breeding populations of Tilapia species are hard to control. It was found that an easy way of controlling them is by the use of Lates niloticus and Hydrocyon species as predators. It has also been noticed that fish production could be stepped up considerably through the use of fertilizers and by keeping pigs by the ponds for utilization of their urine and wastes to fertilize pond water.

Stocking ponds with a number of species at a time, has been demonstrated to yield good results. Enough information has been obtained to guarantee successful commercial pond fish culture in the country.

DEVELOPPEMENT DE LA PISCICULTURE EN ETANG AU GHANA

Résumé

Un programme de pisciculture expérimentale existe au Ghana depuis douze ans. Au cours de cette période, une expérience considérable a été acquise et l'on dispose maintenant de données suffisantes pour passer au stade de l'exploitation commerciale. Les précédents essais de pisciculture commerciale s'étaient soldés par un échec en raison du manque de personnel qualifié et de l'insuffisance de matériel. Les expériences menées avec Tilapia, Labeo, Lates, Synodontis et Bagrus indiquent que ces espèces peuvent être élevées avec succés au Ghana. Les populations de Tilapia s'avèrent difficiles à contrôler en raison de leur tendance à proliférer. Une manière facile de surmonter cette difficulté consiste à introduire dans les étangs à Tilapia des prédateurs appartenant aux espèces Lates niloticus et Hydrocyon. On a également noté qu'il était possible d'augmenter considérablement la production en utilisant des engrais et en élevant des porcs aux alentours des étangs afin d'utiliser l'urine et les excréments de ces animaux pour fertiliser les eaux.

Les essais d'empoissonnement simultané avec plusieurs espèces ont donné de bons résultats. Suffisamment de données ont été recueillies pour garantir le succès de la pisciculture en étang de type commercial.

DESARROLLO DE LA PISCICULTURA EN ESTANQUES EN GHANA

Extracto

Ghana dispone de un programa de piscicultura experimental desde hace doce años. Durante este período se ha aprendido mucho y la información obtenida podría actualmente ser utilizada en un programa de producción de pescado en escala comercial. Los anteriores intentos de cultivo comercial de peces no dieron resultado debido a la falta de personal capacitado y a las dificultades para obtener equipo de campo. Los experimentos mostraron que los peces que pueden ser cultivados con éxito en Ghana son los géneros Tilapia, Labeo, Lates, Synodontis y Bagrus. Dada su prolificidad, las poblaciones de las especies de Tilapia son difíciles de controlar. Se averiguó que una forma sencilla de controlarlas es mediante el empleo de Lates niloticus y especies de Hydrocyon como peces predadores. Igualmente se ha observado que la producción íctica podría elevarse considerablemente con el uso de fertilizantes y aprovechando la orina y desechos del ganado porcino próximo a los estanques para fertilizar el agua de éstos.

Se ha visto que da buenos resultados la población de los estanques con varias especies a la vez. Se ha logrado obtener información suficiente para garantizar el éxito de una piscicultura comercial en el país.

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1 INTRODUCTION

Ghana, situated on the Gulf of Guinea, West Africa, has an area of 91,844 square miles (1,469,504 sq km) and a population of about seven million people. The mean water temperatures are between 26°and 31°C.

Before the creation of the Volta Lake the only lake, a natural lake, existing in Ghana was Lake Bosomtwi near Kumasi. This lake has not supported any large-scale fishery; the physical features of the land around it render it inaccessible. Until recent years the supply of fish in markets all over the country was very limited. Fish obtained from the sea was not enough to satisfy demands because efficient modern fishing craft were not in use. This limited supply of fish, coupled with poor communications and transportation, meant that fish could not be evenly distributed to all parts of the country.

As protein deficiency was most common in the northern parts of Ghana, it was decided that fish culture should be tackled first in these areas. The northern portion of Ghana, about one third of the country, is mostly savanna grassland. Unlike the rest of the country it has only one rainy season a year beginning in April and ending in early October. A good number of streams and creeks are available in these areas but most of them soon dry up when the rains are over. In 1949 the Fisheries Department, despite few personnel, embarked on a program of work on stream improvements in the Lawra and Wa districts. Weirs were built across a number of streams to form pools during the dry season. These pools became a source of fish supply for many of the inhabitants nearby. One problem which came up at that time was that the local people knew nothing about fishing techniques and the staff of the department had to teach the people the techniques of fishing. This program of stream improvement could not proceed for long because there were not enough trained personnel, and facilities for doing this work were not easily obtained. The program was therefore abandoned, and in 1953 the construction of fish ponds started.

A number of small ponds were constructed at Turi-Kalsari near Lawra in the northwest. These ponds were sited below a water conservation dam built by the Tsetse Control Unit then operating in the area and had their water supply from the reservoir created by the dam. This fish farm was to serve as a research station, a demonstration centre for farmers and as a source of supply of Tilapia fry for other farms. These ponds were stocked with Tilapia nilotica, Tilapia zillii and Tilapia galilaea, and two species of Labeo (L. coubie and L. senegalensis). The fishes were obtained from the Kamba and the Black Volta with traps, seine nets and cast nets. The culture of these species in the experimental ponds was proving successful and soon many fry were being produced, but attempts to get the idea of fish farming over to the farmers proved unsuccessful as they had no means of constructing ponds.

2 MANAGEMENT OF WATER CONSERVATION RESERVOIRS AND PONDS

As it became impracticable to construct fish farms the whole project was suspended but fortunately at about the same time, in 1954, the conservation division of the Ministry of Agriculture started construction of water conservation dams in areas around Wa, Navrongo, Bolgatanga and Bawku. The reservoirs were created as sources of water supply for domestic use, for irrigation and for livestock. In the Wa area 17, and in the Navrongo, Bolgatanga and Bawku areas about 150, of these reservoirs have been constructed. They range in size from about 10 acres to about 80 acres (4 to 32 ha) in surface area. The Fisheries Department decided to utilize these reservoirs and 15 of them were stocked in the Wa district with fish obtained from the Turi-Kalsari fish farm.

Stocking of these reservoirs commenced in 1956 in the Wa area, and in 1958 in Bawku, Bolgatanga and Novrongo areas. In 1961 a station was opened at Bawku to coordinate work in these areas. All species involved in this fish culture program except one species belonging to the family Cichlidae are indigenous. The only introduced species, Tilapia macrochir was, as records show, introduced from East Africa into some reservoirs in the Bawku area. The name of the person responsible for this introduction is not on record.

2.1 Species cultured

Species cultured belong mostly to the families Cichlidae, Cyprinidae and Bagridae. The cichlids include Tilapia nilotica, T. zillii, T. galilaea, T. melanopleura, T. macrochir, Hemichromis bimaculatus and H. fasciatus. The cyprinids include Labeo senegalensis and L. coubie. The bagrids include Bagrus bayad, B. docmac, Chrysichthys nigrodigitatus and C. walkeri.

Species belonging to the families Cyprinidae and Cichlidae breed very well in small ponds but the species of the family Bagridae do not often breed in small ponds, although they do breed well in large reservoirs. Occasionally some undesired species appear in these reservoirs. Either they are wrongly introduced or they somehow find their way into these ponds. In so doing they cause the reservoir to be overcrowded and result in desired species becoming stunted.

Some of the species often found present in this way are Clarias spp., Alestes spp., Barbus spp., and some species of the family Schilbeidae.

2.2 Population control in ponds

Besides the presence of undesirable species in these ponds which in many cases cannot be prevented, it is also known from experience that Tilapia are prolific breeders and their populations are hard to control. As a result Tilapia species in such ponds never grow to desired size. Experiments indicated that the use of the predatory Nile perch, Lates niloticus and the tiger fish, Hydrocyon brevis and H. forskali in these ponds is very useful in population control. Not only do these species help to raise desired fish to the required size, but they themselves are good food fish which can be harvested whenever required.

2.3 Production

Annual catch records are maintained by the staff of the Fisheries Department. These figures represent catches made by people dwelling in villages around these reservoirs and and the figures for Wa and Bawku districts are shown in Table I.

Table I

Fish production in four reservoirs in Ghana

Reservoir	Surface area		Year stocked	Fish yields (kg/ha)				
	Acres	Ha		1960	1961	1962	1963	1964
Wa District								
No. 3	40	16	1959	33.5	9.2	31.0	92.0	113.5
No. 5	60	24	1959	21.8	7.5	60.7	99.7	143.5
Bawku District								
No. 10	16	6	1958	-	-	299.2	111.0	75.0
No. 16	18	7	1958	-	-	363.7	75.0	77.7

Species present in these reservoirs included Tilapia nilotica, T. galilaea, T. zillii, T. macrochir, Labeo senegalensis, L. coubie and species of the families Bagridae, Mormyridae and Siluridae. Production figures obtained for these reservoirs since the time they were stocked have not been very encouraging.

2.4 Experiments in rice field fish culture

These experiments were started in 1960 in two ponds (A and B) each of about 1/4 acre (0.1 ha) in size in the Turi-Kalsari experimental fish farm. Pond B was the experimental pond and pond A the control. Experimental pond B was first fertilized with about 10 lbs (4.5 kg) of superphosphate before sowing with swamp rice. After the rice had germinated, the pond was flooded with water and then stocked with 820 Tilapia fingerlings on 13 June 1960. Species used were T. nilotica, T. zillii and T. galilaea (all less than 8 cm long). The same number and size of fingerlings were stocked in control pond A which was flooded with water only and no fertilizers used.

The numbers and sizes of fish harvested are shown in Table II.

Table II

Fish production in experimental ponds in Ghana

Year	1960		1961	
Pond	Rice pond (B) (fertilized)	Control (A)	Rice pond (B) (unfertilized)	Control (A)
No. of fish stocked	820	820	710	710
No. of fish harvested	21,000	12,200	1,997	1,008
Size distribution of fish harvested				
< 10 cm	4,000	3,900	209	308
10 - 14 cm	15,000	8,000	100	200
15 - 20 cm	2,000	100	1,688	500

This experiment was repeated in 1961. But this time no fertilizer was used in the rice pond. At the beginning of the rains in May the ponds were filled with water after pond B had been sown with rice. Both were stocked with 710 Tilapia fingerlings (all less than 8 cm long). Again the species used were T. nilotica, T. zillii and T. galilaea. The fish harvested in November of the same year, six months after stocking, are also shown in Table II.

Results obtained from the above experiments were very encouraging and rice farmers who have their fields flooded during the rains were often advised to stock their fields with Tilapia fingerlings. This idea however did not become popular because the farmers had some difficulties. Most of them had their farms very far away from the Turi-Kalsari fish farm, or far away from any other fish pond where they could obtain fingerlings. Transportation facilities were not easily available to them and the idea could not get good publicity.

2.5 Fish culture and livestock

Another way of improving fish production in ponds involves keeping pigs by the ponds and utilizing their wastes as a source of nitrates for the ponds. A small channel constructed to link the sty and the pond enables pig urine to drain directly into the pond. This is being tried at the Turi-Kalsari fish farm and in the Bawku district. No specific data have been obtained as yet but the general indications are that such ponds are often rich in plankton.

In areas where the reservoirs are intended to provide water supply for livestock, these animals spend most of their time feeding around the catchment areas. Most of their droppings are therefore washed by rains into these reservoirs, enriching them with animal manure. Indications are that such reservoirs are more productive than those providing water for irrigation or for domestic uses. Similarly those reservoirs located in areas of good fertile soil are more productive than those located in areas having poor soil and poor vegetation.

2.6 Other stocking programs

In 1962 a similar program of producing fish in water conservation reservoirs was initiated. A station was opened at Sogakope, 70 miles (112 km) east of Accra, where several reservoirs were stocked with Tilapia species. Production figures for this area are not yet available for inclusion in this paper.

Fish farm construction was also started in 1964 at Dawhenya, 25 miles (40 km) east of Accra. Here three of 13 ponds completed have already been stocked with species of Tilapia and Labeo.

3. PROBLEMS ASSOCIATED WITH FISH CULTURE IN GHANA

(i) Evaporation: Many of these reservoirs dry up completely, or the volume of water becomes very much reduced during the six months dry season, due to high rate of evaporation. This high rate of evaporation coupled with seepage in some of the reservoirs renders them completely unsuitable for fish production.

(ii) Lack of fishing skill: In some cases inhabitants dwelling around these reservoirs have little or no knowledge of fishing techniques and therefore are unable to do any reasonable fishing in them. The result is overcrowding and stunted fish due to insufficient fishing. The Fisheries Department is now teaching these people fishing techniques and methods of making simple fishing gear.

(iii) Fish diseases: So far no serious outbreaks of diseases have been observed in any of the ponds or conservation reservoirs. However, during the rains many of the ponds are heavily infested with leeches, external parasites which attach themselves onto fish skin to suck blood. They have not been observed to cause death in fish.

In the Tongu district where pond fish culture was recently started a parasitic copepod, a species of Lernaea, has been observed to attack Tilapia species in many of the ponds and reservoirs. This parasite causes a red coloured swelling on the body of the fish but has not been observed to cause any mortality.

Pond fish diseases in Ghana need further study.

(iv) Aquatic vegetation: Aquatic weeds commonly present problems in many of the ponds and reservoirs. Sometimes they are not controlled as only mechanical methods of control are applied. Green and blue-green algae sometimes form blooms, and typical land plants sometimes form thick vegetation on the banks, but floating and submerged aquatic weeds are the most common. These include species of Pistia, Ceratophyllum, Nymphaea, Elodea, Potomogeton, the duckweeds, the bladderwort and some swamp grass. The use of herbicides has not been tried as yet, but this should be used if aquatic vegetation is to be kept under control.

4 CONCLUSIONS

Although pond fish culture was initiated some 12 years ago in Ghana, and since then attempts have been made to develop and expand work on it, many problems have hampered progress. The first and foremost problem has been lack of trained field technicians who could handle this work successfully. Another problem has been lack of equipment for field work. However, it is encouraging to observe that with a limited number of field staff some progress has been made. Efforts are being made to train enough field technicians to handle this work successfully. Once these problems are solved, Ghana can look forward to a prosperous program of pond fish culture which would contribute much to her economy.

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THE CULTURE OF TILAPIA SPECIES IN UGANDA

by

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Abstract

Several species of Tilapia have been raised in ponds in Uganda since 1953. Because of their prolific breeding habits, the ponds soon become overcrowded. The size of fish produced is unacceptable to the consumers and the total yield from ponds is low. Little success has been obtained with predators to control the populations. Mono-sex culture through hybridization seems to be the answer to this over-breeding and low yield problem.

L'ELEVAGE DE TILAPIA SPP. EN OUGANDA

Résumé

En Ouganda plusieurs espèces de Tilapia sont élevées en étang depuis 1953. En raison de la tendance de ces espèces à proliférer les étangs deviennent rapidement surpeuplés. Les poissons sont de taille insuffisante pour satisfaire les consommateurs, et le rendement total des étangs est faible. L'emploi de prédateurs pour lutter contre le surpeuplement n'a guère donné de résultats jusqu'ici. Il semble que les problèmes posés par la prolifération et le faible rendement puissent être résolus par l'élevage de Tilapia hybrides d'un seul sexe.

EL CULTIVO DE TILAPIA SPP. EN UGANDA

Extracto

Desde 1953 se han criado varias especies de Tilapia en estanques de Uganda. Dada su proliferación, los estanques resultan superpoblados enseguida. La talla de los ejemplares obtenidos no tiene aceptación entre los consumidores, y el rendimiento total de los estanques es bajo. Poco se ha conseguido con los depredadores para reducir las poblaciones. La solución de este problema de superpoblación y bajo rendimiento parece estar en el cultivo monosexual por hibridación.

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Fish farming started in Uganda in 1953 with the culture of the indigenous tilapia species in small family ponds. The species of tilapia used were Tilapia nilotica, Tilapia zillii and Tilapia leucosticta. These were raised in small ponds constructed on peasants' farms and which rarely exceeded one tenth of an acre (0.04 ha) in area. Prior to the spread of the fish farming idea to the peasant farmers Tilapia spp. had been successfully raised at a government experimental farm at Kijansi near Kampala. However, most of the ponds at the experimental farm were much bigger (about half of an acre - 0.2 ha), well-maintained and the fish were regularly fed. In these respects they greatly differed from the peasant farmers' ponds which were on the whole too small, un-maintained and the fish were only occasionally fed. Although the Fisheries Department had tried its best to advise on the siting, construction and maintenance of ponds, the demand for ponds from the farmers was so great that the department, with its limited staff, could not cope with the supervision of the thousands of ponds that were being constructed.

At Uganda temperatures (15° to 36°C), various species of Tilapia reach sexual maturity in ponds at the age of about six months when about 200 g weight. The fish then begin to breed and breeding is prolific and at very frequent intervals. Populations build up to overcrowding levels, the food supply becomes insufficient and growth rates of all sizes of fish are slowed down appreciably. Each succeeding generation reaches maturity at a smaller size and the ponds become overcrowded with stunted fish. Such small bony fish are entirely unacceptable to the farmers who prefer a few but good-sized table fish (around 400 g). The fish farming program was therefore immediately faced with the problem of producing the size of fish that was acceptable to the farmers. As this stunting was due to the lack of food in the ponds for the rapidly multiplying population, there seemed to be two lines of approach to this problem. One was to increase the food supply in the ponds, and the other to reduce the number of fish so that the few remaining could get enough to eat and achieve better growth rates. Both these methods were tried.

The pond fish were fed regularly with choppings of elephant grass (Pennisetum purpureum), sweet potatoe leaves (Ipomaea batatas) and any other soft vegetation which the fish could take. This type of feeding alone, however, was not sufficient since not all the species of Tilapia that were being used ate higher plant material. T. leucosticta feeds on phytoplankton and bottom deposits formed largely from the decomposition of phytoplankton from the upper layers. Therefore, in ponds lacking phytoplankton T. leucosticta rarely grew to a desired size. T. nilotica feeds mainly on phytoplankton either in suspension or from the bottom deposits. It also feeds on insects and crustaceans and under certain conditions will digest blue-green algae. T. zillii on the other hand feeds on leaves and stems of rooted aquatic plants and their associated epiphytic algae, and this species could therefore be fed on the higher plants as described above.

Of the three species of tilapia used, Tilapia leucosticta was soon eliminated as being unsuitable for culture because of its feeding habits. In addition this species is a prolific breeder and in all ponds where it had been stocked, overcrowding and stunting had occurred much to the discouragement of the fish farmers. Tilapia nilotica and Tilapia zillii were therefore favoured, and of these two, T. zillii seemed to be the most suitable. However, in practice, farmers rarely fed their pond fish and because of under-feeding, T. zillii in those ponds were very small in size but bred prolifically. Farmers were therefore discouraged from using this species unless it was grown in combination with T. nilotica.

Because the different tilapia species used were not all vegetation feeders, fertilization experiments were carried out to encourage the growth of the organisms utilized by the other species. Most Uganda waters have a low pH, and there is a general lack of calcium, phosphates and sulphates. Organic fertilizers (manure, cowdung, and poultry droppings) were first tried. These could be obtained by most of the farmers at no cost, unlike the industrial fertilizers which were on the whole very expensive. These organic fertilizers, however, did not seem to be useful, for although they encouraged the growth of some algae like Spirogyra and Microcystis, they were on the whole not utilized by the tilapia. At the experimental farm superphosphates were therefore tried and the chemical results obtained after fertilization of one pond were as follows:-

Total organic nitrogen increased from 3.36 mg/ℓ to 6.5 mg/ℓ; nitrates increased from nil to 0.1 mg/ℓ; phosphate from nil to 2 mg/ℓ; ammonia from 0.03 mg/ℓ to 1.76 mg/ℓ; and albuminoid nitrogen from 0.8 mg/ℓ to 1.2 mg/ℓ. (FAO/UN, 1961).

Because of the low pH in most areas in Uganda, to obtain better results with these superphosphate fertilizers it was first necessary to lime the ponds. But, although these increases in some of the chemical substances in the water were often accompanied by increases in the phytoplankton and zooplankton, these were so short-lived that the cost of obtaining an increase in the total production of fish from these ponds by this method would have been prohibitive.

Green manure, such as nitrogen fixing plants, was also used in Kajansi. Ponds were planted with beans (Phaseolus spp.) and when they were beginning to flower these were cut down and the ponds flooded. This too, did not prove satisfactory for due to the rapid decomposition at the bottom of the pond, there was in most cases de-oxygenation and the fish died.

Combinations of T. nilotica and T. zillii when regularly fed in fertilized ponds usually produced good results in the first generations. However, uncontrolled breeding soon led to overcrowding in the succeeding generations with resulting stunted populations. It was not possible to produce enough food in the ponds, and even in those ponds where the food seemed to be adequate the tilapia, due to their specialized feeding habits, did not fully utilize all the available resources. Population control measures were therefore necessary. Two approaches to this problem were attempted. One was to use a predator, and the other one to use mono-sex cultures.

Two predators were tried in mixed cultures with tilapia: the largemouth black bass (Micropterus salmoides) and the Nile perch (Lates niloticus). The black bass used in these experiments were obtained from Kenya and had probably been acclimatized to East African conditions. They grew well at Kajansi Fish Farm, but did not spawn. They were not effective in controlling a breeding population of tilapia. The experimental ponds had a very high population of tadpoles and it is possible, as some other workers have shown (Lewis and Helms, 1964) that these formed an easier prey than tilapia fry. The Nile perch on the other hand proved to be a more efficient predator, and in the experimental ponds with Nile perch, stocked at a rate of 1 : 30 (sizes adjusted), the tilapia populations were kept at a minimum and attained better growth rates. Although the Nile perch bred once in Kajansi, it was not found possible to repeat the breeding to obtain Nile perch fingerlings in sufficient numbers for experimentation in the farm or elsewhere. This proved a handicap to the experiments and they had to be abandoned.

Efforts were now directed to mono-sex culture. The first experiments were made by Wurtz in 1959-60 (FAO/UN, 1961). Wurtz tried mono-sex cultures of T. nilotica and T. zillii based on visual identification of the males and females of tilapia between 2.5 cm and 5 cm in length. Because of the difficulty in sexing these species at this age, they did not prove very successful as breeding often occurred in what had been thought to be a mono-sex culture. In these two species of tilapia, unlike T. nigra, the sexes do not grow at greatly different rates, and the sexes could therefore not be separated by mechanical devices.

Hickling (1960) working with Tilapia sp. in Malacca, experienced similar overcrowding problems, and although he could easily sex the fish, the job was tedious and wasteful in that if only males were to be used, the females were wasted. Hickling therefore resorted to hybridization, and as is now well known, he found that the cross between female Malayan-acclimatized T. mossambica and male Tilapia hornorum from Zanzibar produced 100 percent male offspring. These could be used for stocking without danger of breeding. (The reverse cross produced 75 percent males).

Several tilapia crosses have now been tried at Kajansi, with the assistance of Mr. Y. Pruginin, FAO/TA Fish Culturist. One of these, T. mossambica (male) and T. nilotica (female), has produced results similar to those obtained by Hickling - almost 100 percent

males. The hybrids obtained from these crosses are fertile and reach maturity at about five to six months. In the aquarium tanks where they have been observed they develop breeding colours and periodically dig nests. A back cross is also possible. They have fast growth rates and some individuals have grown up to 150 g in one month. In ponds the hybrids have given higher yields than have hitherto been obtained with wild populations. Yields of up to 1,000 kg per ha per annum have been obtained in ponds with little or no supplementary feeding as compared with 300 kg originally obtained with wild tilapia populations in well fed ponds. The fish population in the ponds can be controlled at the required density.

In conclusion, mono-sex cultures of tilapia through hybridization seem to be the answer to the overbreeding problem that occurs in populations of tilapia in ponds. The technique is receiving great attention in Uganda. Hybrids are easy to obtain and give a higher total yield per ha of water. The method is recommended for fish culturists in tropical areas using tilapia. It is also hoped that through hybridization it will be possible to obtain a tilapia that will usefully utilize all the available food resources in ponds.

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CARP CULTURE IN THE U.A.R.

by

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CARP CULTURE IN THE U.A.R.

Abstract

The two varieties of common carp (scale carp and mirror carp) have been successfully introduced in the U.A.R. Most of the experiments and culture of carp were conducted in Barrage, Serow and Manzallah Farms. The first two farms are experimental while the last one is a commercial farm.

Carp spawned with satisfactory results in cement tanks with hard bottom. Egg collectors made of palm leaves covered with red palm fibres are used for attachment of eggs. Nursing experiments showed that 75,000 to 100,000 carp fingerlings, about 10 cm in length can be obtained per hectare of nursing ponds in about one month.

Examination of the Egyptian carp stock revealed the fact that only 17.13 percent of the examined fish possessed desirable body characters. After careful selection of the mothers, this ratio increased to 67.95 percent. Such improvement was reflected in the production per hectare, which was much higher in the case of the selected fish.

From carp production experiments conducted in Serow ponds, it was found that rearing carp fry alone produced 377 kg/ha (gain in weight) under natural conditions. By the addition of adult tilapia, a total production of 711 kg/ha was secured. Rearing a combination of carp fry, mullet fry and adult tilapia produced 800 kg/ha. Carp fry and indigenous fishes produced an average of 1,088 kg/ha. All these combinations were produced under natural conditions.

One-year-old carp, mullet and adult tilapia with feeding and fertilization produced 1,218 kg/ha. Rearing of tilapia as a supplementary fish with carp in our ponds is highly recommended.

200 kg per hectare can be produced from rearing carp in rice fields in two to three months. Rearing carp in only half of the rice fields in Egypt will produce about 30,000 metric tons every year.

No disease of any importance has affected our carp or caused great mortalities.

LA CARPICULTURE DANS LA R.A.U.

Résumé

Les deux variétés de carpe commune (la carpe "à écailles" et la carpe "miroir") ont été introduites avec succès dans la R.A.U. La plupart des expériences d'élevage ont été menées dans les établissements piscicoles de Barrage, Serow et Manzallah. Les deux premières sont des stations expérimentales et la dernière est un établissement commercial.

Les carpes se sont reproduites de manière satisfaisante dans des bassins cimentés à fond dur. Des collecteurs d'oeufs en feuille de palmier recouverts de fibres de palmier rouge sont utilisés pour permettre la fixation des oeufs. Des expériences ont montré qu'en étang d'alevinage on pouvait obtenir, en un mois environ, de 75 000 à 100 000 carpillons de 10 cm per hectare.

Des prélevements sur le stock égyptien de carpes a révélé que 17,13 pour cent seulement des poissons examinés possédaient les caractéristiques physiques souhaitables. Une sélec-

tion attentive des mères a permis de porter ce taux à 67,95 pour cent. Cette amélioration s'est répercutée sur la production à l'hectare qui était beaucoup plus élevée dans le cas des poissons sélectionnés.

Des expériences de production menées dans les étangs de Serow ont montré que l'élevage de carpillons seuls produisait 377 kg/ha (gain en poids) dans des conditions naturelles. En ajoutant des tilapia adultes, on a obtenu une production totale de 711 kg/ha. Avec une combinaison d'alevins de carpe et de mulet et de tilapia adultes la production est passée à 800 kg/ha. Avec des alevins de carpes et des espèces indigènes on a obtenu en moyenne 1088 kg/ha. Toutes ces associations ont été essayées dans des conditions naturelles.

Avec un apport de nourriture artificielle et d'engrais, on a obtenu, en associant carpes d'un an, mulets et tilapia adultes, une production de 1218 kg/ha. L'élevage du tilapia comme espèce accessoire avec la carpe est fortement recommandé dans nos étangs.

L'élevage de carpes dans les rizières permet de produire 200 kg à l'hectare en deux ou trois mois. L'adoption de cette pratique dans la moitié seulement des rizières égyptiennes permettrait de produire 30 000 tonnes chaque année.

On n'a jamais constaté en Egypte de maladies importantes de la carpe ayant provoqué de fortes mortalités.

EL CULTIVO DE CARPAS EN LA R.A.U.

Extracto

En la R.A.U. se han introducido con éxito las dos variedades de carpa común: carpa escamosa y carpa de espejos. Casi todos los experimentos, así como el cultivo de carpas, se realizaron en las granjas de Barrage, Serow y Manzallah. Las dos primeras son experimentales en tanto que la última es una granja comercial.

La carpa desovó con satisfactorios resultados en depósitos de cemento con fondo duro. Para que se adhieran los huevos se emplean colectores hechos de hoja de palma cubiertos de fibras de palma roja. Los experimentos de cría mostraron que en un mes, aproximadamente, se pueden obtener de 75.000 a 100.000 jaramugos de carpa de unos 10 cm de longitud por hectárea de estanque de cría.

Un exámen de las poblaciones de carpas egipcias reveló el hecho de que sólo el 17,13 por ciento de los peces examinados poseían los caracteres físicos deseables. Después de una cuidadosa selección de las madres esta proporción aumentó al 67,95 por ciento. Tal mejora se reflejó en la producción por hectárea que fué mucho más elevada en el caso de los peces seleccionados.

En los experimentos de producción de carpas realizados en los estanques de Serow se comprobó que criando únicamente jaramugos de carpa se lograron 377 kg/ha, (aumento de peso) en condiciones naturales. Mediante la adición de tilapias adultas, se obtuvo una producción total de 711 kg/ha. Criando simultáneamente jaramugos de carpa, jaramugos de lisa y tilapias adultas se obtuvo una producción de 800 kg/ha. Los jaramugos de carpa y los peces indígenas dieron un promedio de 1.088 kg/ha. Todas estas combinaciones se criaron en condiciones naturales.

Carpas de un año, lisas y tilapias adultas, con alimentación artificial y fertilización, produjeron 1.218 kg/ha. Es muy recomendable la cría en estanques del país de tilapia como pez suplementario de la carpa.

En dos o tres meses se pueden obtener 200 kg/ha con la cría de la carpa en arrozales. La cría de la carpa en la mitad solamente de los arrozales de Egipto produciría unas 30.000 toneladas métricas anuales.

Ninguna enfermedad de importancia ha afectado a nuestra carpa o ha causado mortandades grandes.

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1 INTRODUCTION

The total fish production in the U.A.R. from the sea and inland waters was recently estimated to be about 124,159 metric tons. About 50 percent of this quantity is derived from natural inland waters, i.e. from the river Nile and two lakes.

The increasing demand for more fish has resulted in greater attention being paid to fish culture in Egypt. Various types of fish culture have been practised in the country, but it was not until 1934 that carp (Cyprinus carpio) culture was started. Since then carp culture has developed well all over the country.

Many papers have been written on carp in Egypt (Koura and El Bolock, 1960; Imam and Shaheen, 1960; Imam, Shaheen and Hashem, 1960 and FAO/UN, 1960 and 1963). In this paper it is proposed to review fully all information available on carp culture in Egypt, with special reference to the work done by the present authors on carp production under different conditions in the Serow Experimental Fish Farm.

2 DESCRIPTION OF THE FISH FARMS

Carp culture is practised in Egypt in many widely separated centres, the most important of which are Barrage, Serow and Manzallah farms.

2.1 Barrage Experimental Fish Farm

This farm established in 1929 at El Kanatir El Khairia near Cairo, has 14 spawning, nursing and experimental ponds varying in area from 50 to 1,800 m^2. The water supply is from an irrigation canal of the Nile. Every pond has an inlet and an outlet and is easily irrigated and drained. This farm is mainly meant for experiments in the acclimatization of exotic fishes. The common carp, Cyprinus carpio (scale type), the mirror carp, Cyprinus carpio v.specularis, the black bass, Micropterous salmoides, Tilapia mossambica, and the silver carp, Hypophthalmichthys molitrix, were received in this farm from 1934 to 1962. The suitability of indigenous fishes for culture is also studied here.

2.2 Serow Experimental Fish Farm

This farm was established in 1949 on the southern shore of lake Manzallah. It has 46 spawning, nursing, experimental and rearing ponds, and a total area of 12 ha. The water supply is taken from a nearly fresh-water canal near the farm. The spawning ponds (50 m^2) are concrete built with hard bottom. The small experimental ponds are also concrete built with a muddy layer on the bottom. The nursing ponds (500 m2) and the rearing ponds (0.4 - 2 ha) are normal mud ponds and are easily filled and drained. This farm is considered as an ideal one for fish culture experiments. It is also used as a training centre for fish culture in Egypt.

2.3 Manzallah Fish Farm

This farm located about 30 km south of the Serow Farm was established in 1957. It consists of 38 spawning and nursing ponds varying in area from 50 to 1,000 m^2, and 15 rearing ponds 6 ha each. In addition, there is a large water area of about 280 ha. The water of this farm is slightly brackish (chlorinity from 1.1 to 8.6 g/l). However, a connection to the fresh-water canal is proposed and is now under construction. The ponds of this commercial farm are easily filled, but pumps are used for drainage.

3 ACCLIMATIZATION OF CARP

The common carp (scale type) was introduced from Indonesia in 1934. Two hundred and two carp fingerlings varying in size from 5 to 8 cm were planted in Barrage ponds where they reached 46 cm in two years. Carp spawned successfully under good control in the spring of 1936 when the water temperature reached 22°C. Different methods for collecting

carp eggs were used. The most successful of these methods was the use of the frame-like collectors made of palm leaves and covered with red palm fibres. The collectors carrying the fertilized eggs were transferred to well managed and clean nursing ponds where the eggs hatched and the fry were nursed for about one month. The large number of carp fingerlings thus produced were distributed to the private farms for rearing. However, this variety of carp was not appreciated by our people and later on in 1949, it was replaced by the mirror carp.

The mirror carp was introduced from France, in the Barrage Farm where their acclimatization and spawning was completely successful (Koura and El Bolock, 1960). In the Barrage Farm , mirror carp attained a relatively high rate of growth (about 18 cm in length and 123 g in weight) in its first year of life. However, still higher growth is attained in Serow Farm (see 4.2).

From Barrage Farm, the mirror carp was transferred all over the country. Mirror carp were even exported to Saudi Arabia and Syria. The results of carp introduction in Saudi Arabia are not known, but the carp sent to Syria and reared at Kalaat El Moudik Fish Farm have established successfully (Beckman, 1959; FAO/UN, 1962).

4 EXPERIMENTS IN SEROW FARM

Mirror carp was first transferred to the Serow Farm in 1956. Spawning occurred successfully in cement tanks with no muddy bottom. When the bottom is muddy, the splashing of the spawners cause mud to deposit on the eggs, causing great losses. The usual palm leaf collectors (80 x 110 cm) are used for the attachment of eggs. About 22 to 25 of these collectors are placed obliquely along the sides of the spawning ponds. The collectors carrying the eggs are either transferred directly to the nursing ponds where the eggs hatch and the fry live up to the end of the nursing period, or are first transferred to hatching ponds and then the larvae are transferred to the nursing ponds in the required numbers. The last practice proved more beneficial since the survival ratio of the fry was better than in the first practice.

Experiments showed that an average of 75,000 to 100,000 carp fingerlings of about 10 cm length can be obtained per ha of well managed and fertilized nursing ponds. The nursing period is usually about one month. Carp fry produced in spring are more healthy and show better growth than those produced in autumn (September). This is due to the greater abundance of plankton in the ponds in spring.

4.1 Improvement of carp body characters

The examination of 5,000 carp varying in age from 1 to 4 years revealed the fact that only 17.13 percent possessed the desired body characters. These characters are: the possession of a small head, absence of malformations of body and fin, presence of scales only on the fin bases and a relatively high back. As regards the last character, the body length/height ratio ($\frac{L}{H}$) varies from 2.1 to 3. However, such ratio is elastic and can be easily improved through external conditions (Schäperclaus, 1961). The remaining 82.87 percent are considered bad in all characters. They possess big heads, malformations are common on the body and fins, and scales are either lacking or badly distributed all over the body. To improve the body characters of our carp stock, the best and easiest method i.e the selection of the present mothers and the development of an excellent race of future mothers was adopted in spring 1963. In 1965, 5,000 yearlings produced from well selected mothers were examined. The new generation showed much improvement in body characters. The percent of fish with the desired body characteristics reached 67.93 after selection.

The effect of the improvement in body characters on carp growth and consequently on production per ha is shown by the results given in Table I. In this experiment, two ponds 0.4 ha each were stocked with one-year-old carp at the rate of 1,000 ha. While the first pond was stocked with well selected carp, the second pond was stocked with unselected carp of the old stock. Supplementary food (cottonseed cake and rice bran, 1:2) at a rate of ten

percent of the total fish weight was given in each pond. The loss was small in both cases. From the Table it is clear that the growth (gain in weight/individual fish) of the first group is 3.4 times more than that of the second group. Part of this increase in growth is attributed to the longer rearing period of the selected fish. However, the fish with good body characters are no doubt more healthy and more able to make use of the natural and additional food in the pond and thus grow faster than the others. This fast growth is reflected in turn in higher production per ha.

Table I

Effect of improvement in carp body characters on growth and production

Stocked fish	Stock No./ha	Av. wt of fish at stocking (g)	Duration of rearing (days)	Av. wt of fish at fishing (g)	Gain in wt/ fish (g)	Per ha gain in weight (kg)
Selected carp	1,000	85	378	800	715	708
Unselected carp	1,000	61	319	268	207	263

4.2 Carp production experiments

A series of experiments to determine carp production per ha is being carried out in the Serow Fish Farm. The purpose of these experiments is to find out the conditions that give the maximum production at the lowest cost. The experiments done in 1964-1966 are discussed below.

The ponds used for the experiments were 0.4 to 2 ha in water area. The water level ranges from 120 to 180 cm. The water supply is nearly fresh (chlorinity from 0.3 to 0.7 g/l). The ponds are rich in the natural food for fishes, both plankton and bottom fauna.

Fry as well as one-year-old selected carp were used in these experiments. Grey mullet (Mugil capito), both fry and one-year-old, as well as adult Tilapia were used as supplementary fish. Both mullet fry and adult Tilapia can be easily fished in large quantities from the nearby canals and drains. The species of Tilapia used were T. galilaea (60 percent), T. zillii (30 percent) and T. nilotica (10 percent). As supplementary food, cottonseed cake and rice bran at a ratio of 1:2 were given.

4.2.1 Carp cultured under natural conditions

Under the natural conditions, without fertilization or artificial feeding, the production amounted to 377.2 kg/ha (see Table II) in Serow Farm.

Table II

Carp fry production under natural conditions

Stock (No. per ha)	Av. wt of fish at stocking (g)	Duration of rearing (days)	Loss per-cent	Av. wt of fish at fishing (g)	Gain in wt/fish (g)	Per ha gain in weight (kg)
5,000	5	212	42	138	133	377.2

Total harvested fish = 402.2 kg + 45 kg of other fishes.

However, the bottom of the pond was well managed, i.e. it was left to dry for a long period and was lightly ploughed. About 45 kg of other fishes (mostly Tilapia and Lates niloticus) were also found in the pond.

The presence of Lates niloticus in the pond is no doubt responsible for the high loss of carp fry stocked. Riedel (FAO/UN, 1962) estimated the natural production of El Ghab ponds in Syria to be 350 kg/ha. In Israel 200 to 400 kg/ha can be produced under natural conditions (Jones, 1956). In Lebanon, 500 kg of carp per ha was found to be produced under natural conditions in Terbol Fish Farm at Bekka Valley (Timmermans, 1960). In some German ponds (at Wielenbach), an average of 94 and 102 kg of carp per ha was produced without feeding or fertilization. Further experiments on the natural productivity of our ponds are planned. However, we can safely say that 370 kg/ha can be produced under natural conditions in well managed ponds of Serow Farm.

4.2.2 Carp cultured with Tilapia under natural conditions

Rearing of carp fry together with Tilapia under natural conditions was also conducted in Serow ponds. The Tilapia spawned and propagated themselves in the ponds during the rearing period. The result of this association is shown in Table III. A production of 711.2 kg/ha of fish was obtained from the pond, 57.8 percent of which was carp, while the remaining 42.2 percent was Tilapia. The gain in weight of Tilapia could not be calculated due to the propagation of these species in the pond. The relatively low weight of individual carp may be due to crowding. However, the per ha carp production was not affected by the presence of Tilapia and an additional 300 kg was obtained due to Tilapia.

Table III

Carp fry and Tilapia produced under natural conditions

Stocked fish No./ha	Av.wt of fish at stocking (g)	Rearing period (days)	Loss percent	Av.wt of fish at fishing (g)	Per ha gain in weight (kg)	Total harvested fish/ha (kg)
5,000 carp	5	196	7.6	89	386.2	411.2
1,250 tilapia	-	361	-	-	-	300

Total = 711.2 kg/ha

4.2.3 Carp cultured with mullet and tilapia under natural conditions

A still higher fish harvest was obtained when mullet fry were added to the previous association (see Table IV).

Table IV

Carp fry, mullet fry and tilapia under natural conditions

Stocked fish No./ha	Av. wt of fish at stocking (g)	Rearing period (days)	Loss percent	Av. wt of fish at fishing (g)	Per ha gain in weight (kg)	Total harvested fish/ha (kg)
5,000 carp	6	196	25	91	311.3	341.3
2,500 mullet	2	277	48	83	99	104
1,250 tilapia	-	313	-	-	-	355

Total = 800.3 kg + 65 kg of other fishes/ha

The new association produced 800 kg of the stocked fish per ha. An excess amount of 65 kg of other fish was also secured from the pond. The weight per individual carp produced is still lower than that in case of rearing carp fry alone. The per ha gain in weight of carp was also somewhat affected by the population density. However, the end result of this association under the conditions prevailing in the pond is not bad.

4.2.4 Carp cultured with indigenous fishes under natural conditions

Another important result was obtained when carp was reared together with indigenous fishes found in our natural waters. Nile water at the beginning of the flood season was introduced in a pond about two ha in area. In this pond carp fry were also stocked at a rate of 2,500 ha. At the end of the rearing period (190 days) a total harvest of 1,200 kg of fish was obtained. The production consisted of 55 percent Tilapia, 20 percent carp, 17 percent mullet (Mugil capito) and 8 percent other fishes including Labeo spp., Bagrus bayad, Clarias lazera and Lates niloticus. The last two species increased the loss of carp to about 70 percent. In a less fertile pond of the same water area, the same association produced 977 kg of fish per ha.

4.2.5 Intensive culture of one-year-old carp, mullet and tilapia

In order to find out to what extent rearing of one-year-old carp and mullet is beneficial, an association of one-year-old carp, mullet and tilapia was stocked at the stocking rates shown in Table V. In this case additional feeding (2,500 kg/ha) was given. The pond was also fertilized with organic fertilizer (cowdung) at the rate of 1,000 kg/ha. The fertilizer was applied in heaps along the margins of the pond.

From the Table it is evident that the loss was negligible in both carp and mullet. This is no doubt due to the fact that the stocked fishes were big enough to protect themselves. It is also found that the gain in weight per individual carp is 3.1 times and of mullet 3.6 times more than that attained in combined culture under natural conditions (see Table IV).

When we exclude the production of Tilapia in both associations (Tables IV and V), we find that rearing one-year-old carp and mullet produced 276.5 kg of fish flesh more than by rearing fry. If we consider the total harvested fish in both cases, we find that the one-year-old carp, mullet and adult tilapia association produced (with additional feeding and fertilization) 353 kg of fish per hectare more than the association shown in Table IV (excess fish found is included).

Table V

Rearing one-year-old carp, tilapia and mullet with feeding and fertilization

Stocked fish No./ha	Av. wt of fish at stocking (g)	Rearing period (days)	Loss percent	Av. wt of fish at fishing (g)	Per ha gain in weight (kg)	Total harvested fish/ha (kg)
1,250 C	55	371	0.8	320	328	396.8
1,250 M	50	371	-	337	358.8	421.3
1,250 T	-	371	-	-	-	400

Total = 1,218.1 kg/ha

C = Carp
M = Mullet
T = Tilapia

It was also noticed that the already ripe one-year-old carp had spawned in the pond. However, carp propagation was severely controlled by Tilapia. Tilapia are known to devour large quantities of carp eggs (Imam and Shaheen, 1960). So, there is no fear of over-population of the pond with carp fry when rearing one-year-old fish.

4.2.6 Conclusions and observations on carp production

From the results obtained in carp production in Serow ponds, it is concluded that 370 kg of fish flesh can be produced by growing carp fry under natural conditions. Rearing adult Tilapia together with carp fry has not only not decreased carp production, but has increased the total yield by 209 kg. The addition of mullet fry to the previous association has slightly affected carp production, but the total yield is still higher than that of carp alone by 398 kg, and of carp-tilapia combination by 89 kg.

Rearing a combination of one-year-old carp and mullet, and adult tilapia produced 1,218 kg of fish per ha, 418 kg more than the combination of carp fry, mullet fry and adult tilapia. The weight of the undesired fishes found in the ponds is not included in this comparison.

In the above combinations, tilapia production reached 32 to 55 percent of the total harvested fish. Since tilapia (i) is easily available for stocking, (ii) does not compete with carp for its natural food, and (iii) is much appreciated by consumers, its rearing as supplementary fish in our ponds is highly recommended.

5 CARP CULTURE IN RICE FIELDS

Fish culture in rice fields is of great economic importance in many countries of the Far East such as Japan, China and Indonesia. In Egypt fish culture in rice fields was first started in 1954 (Saheen, Imam and Hashem, 1960). When carp from 20 to 56 g in weight are stocked in rice fields at a rate of 750 to 1,250 fish per ha and reared for about two to three months, a total catch of about 200 kg of carp can be obtained, the gain in weight being about 88 to 186 g per individual fish. At the same time, the rice crop itself can be increased by five to seven percent as a result of raising fish in rice fields.

In the U.A.R. we have about 300,000 ha of rice fields. If carp culture is practised in even half of this area, an amount of about 30,000 metric tons of fish can be obtained every year. Preparing carp fingerlings and yearlings for such vast areas of rice fields is a matter of great importance.

6 PARASITES AND DISEASES

No disease that causes great mortality in carp has been recorded in our ponds. It is also fortunate that ascities (the infectious carp dropsy) has not infected our carp. The fish louse (Argulus pillucidus) has been recorded in the Barrage Farm in 1952, but it was easily controlled. In summer months with high water temperatures that reach a maximum of 33°C, some mortality occurs due to oxygen deficiency. However, this is easily controlled by letting fresh oxygenated water in the affected ponds.

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